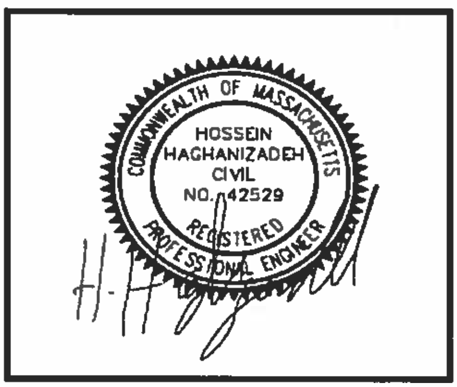
HYDROLOGY & STORMWATER MANAGEMENT REPORT

ABBY WOODS DEFINITIVE SUBDIVISION

February 11, 2020

PREPARED FOR:

MASSACHUSETTS HOME BUILDERS LLC
125 OLEAN STREET
WORCESTER, MA 01602



PREPARED BY:

HS&T Group
75 Hammond Street
Worcester MA 01610

CALCULATIONS AND REPORT BY Lesley Wilson

ABBY WOODS

PROJECT SUMMARY

Existing Conditions and Site Description

Abby Woods is located off the easterly side of Carroll Road.

Abby Woods proposes one dead end road in Abby Road. Abby Road contains 500' of roadway alignment. The road will provide a conventional cul-de-sac at the terminus. Post-development, the proposed Abby Woods subdivision will consist of 10 lots, totaling 12.4 acres.

The parcel is mapped on the Town of Grafton zoning map in the Medium Density Residential (R-20) district. The site soils have been identified from the USDA NRCS Soil Survey of Worcester County, Massachusetts, Southern Part, and consist of 305C Paxton and 315B Scituate, and are classified as Hydrologic Soil Group (HSG) C under the USDA. A copy of the USDA SCS Soil Survey Tables and Map can be seen in the attached appendices. The limits of the mapped 100- year flood zone as identified the NFIP Firm Community Panel 25027CO829E dated July 4,2011 is depicted on the plans. The proposed plans do not propose any filling within the flood plain. There is a delineated wetland that is located to the rear of the proposed subdivision. No filling in the wetlands is proposed. The site is not subject to the Rivers Protection Act and there are no other regulated resource areas, aside from the BVW, within 100' of the proposed work, and the site is not in a designated ACEC.

Hydrologic Analysis Summary

The subdivision proposes 10 total lots. There are three existing structures on-site, a single-family house, a barn and a large shed. There is a gravel drive that leads from Carroll Road to the existing structures. The remainder of the site is a combination of wild un-maintained growth and wooded areas.

A hydrologic analysis for SCS-TR 20, Type III- 24 hour, 2, 10, and 100-year storms have been conducted on the site in order to evaluate the pre-development and post-development runoff rates and to provide a BMP for the site in an effort to improve site runoff conditions. The 25-year storm event was evaluated to properly size the closed drainage system and can be seen in spreadsheet format in the attached appendices.

Under existing conditions, stormwater flows northwesterly into Carroll Road and southwesterly into the existing wetland system these two points have been defined for calculation purposes as the site Point of Interests (POI). The runoff is confined mainly within the property boundaries; to the south is the Grafton-Upton Railroad; and to the west is a large hill (most-likely ledge outcrop). These natural features prevent off-site water from influencing our drainage analysis.

The proposed closed drainage system consists of a series of stormwater collection structures, i.e., deep sump catch basins and drain manholes. The site drainage is collected in two drainage systems. Runoff from the first closed systems is directed to the sediment forebay and Detention basin for treatment of sediment, TSS removal, and discharge to the abutting wetlands. The second closed system is directed to a downstream defender before being connected into the existing drainage system on Carroll Road.

Hydrologic Analysis

HS&T Group, Inc. used HydroCAD software, Version 8.50 to conduct hydrologic analyses. The HydroCAD model uses "nodes" to represent different natural and proposed features. The following is a brief description of each type of HydroCAD node used:

SUBCATCHMENT-relatively homogenous area of land that drains into a single reach or pond. Models the effect of rainfall on a specific section of the watershed, and produces a runoff hydrograph. Subcatchments are described by a number of parameters such as area, curve number, and time of concentration. A subcatchment may also be used to model the water falling directly on the surface of a pond.

REACH-models the effect of a hydrograph being routed through a uniform stream, channel, or pipe under open-channel flow conditions. This results in attenuation and delay of the peak flow due to the storage and travel time of the reach. Note that when a subcatchment feeds a reach along its length, it should generally be treated as a component of the Tc calculation for the subcatchment, and not as an independent reach.

POND- An impoundment that fills with water from one or more sources and empties in a manner determined by a weir, culvert or other outlet device(s) and models the storage effects of any retention or detention area, such as a reservoir, detention pond, or storage chamber. A pond can also incorporate a variety of any outlet control devices, such as culverts, weirs, etc., with the ability to account for headwater and tailwater effects. An optional secondary outflow can be used to divert part of the outflow for independent routing.

LINK- used to enter a hydrograph generated outside HydroCAD, or to interconnect several routing diagrams. A link can also be used to scale a hydrograph, to split it into two components for independent routing, or to define a fixed or tidal tailwater elevation for certain routing methods.

HydroCAD uses the following equations to calculate the travel time for sheet flow and shallow concentrated flow. The calculated travel times and variables for each catchment area can be seen in the attached HydroCAD data.

Travel Time for Sheet Flow:

$T_T = [0.007(nL)0.8]/[P_2^{0.5}S^{0.4}]$

n = Manning's Coefficient
L = Flow Length (ft.)
P_2 = 2-year 24 hour rainfall (inches)
S = Land Slope (ft./ft.)

Travel Time for Shallow Concentrated Flow:

$T_T = L/(3600V)$

L = Flow Length (ft.)
V = Average Velocity (fps) = $(K_V)(S^{0.5})$
K_V =Velocity Factor (fps)
S = Land Slope (ft./ft.)

The analysis points have been evaluated under the pre-development and post-development conditions to estimate the stormwater runoff rates under the 2-year, 10-year, and 100-year, Type III, 24-hour storm events. Rainfall values for each of these return periods have been obtained from the NOAA Atlas 14, Volume 10, Version3. Copies of the atlases can be seen in the attached appendices.

Return Period	Rainfall (in.)
2 YEAR	3.27
10 YEAR	5.04
100 YEAR	7.84

Table 1.0: 24 Hour Rainfall Values Utilized

The HydroCAD data generated in the analysis for each return period has been enclosed in the attached appendices.

MSMP Standards

Each BMP has been designed in accordance with the Massachusetts Stormwater Management Policy (MSMP) Volumes I and II and III. The following is a summary of the purpose and design of each BMP used as it relates to the guidelines specified in the MSMP Vol. II on a point-by-point basis. The proposed drainage system meets the Stormwater Management Policy of the Massachusetts Department of Environmental Protection as follows:

Standard #1 - No Untreated Stormwater:

No new stormwater conveyances discharge untreated stormwater directly to, or cause erosion to wetlands or waters of the Commonwealth.

Standard #2 – Post Development Peak Discharge Rates:

The Stormwater Management System is designed so that the post-development peak runoff rates do not exceed pre-development peak discharge rates.

Stormwater controls have been designed for the 2, 10 and 100-year storms. The post-development rates for these storms are less than the pre-development runoff rates.

The results of the Hydrology Analysis for the pre-development and post-development conditions are as follows:

STORM EVENT	2-YEAR	10-YEAR	100-YEAR
Subcatchment 1			
PRE DEVELOPMENT RATES (cfs):	3.88	9.5	19.46
POST DEVELOPMENT RATES (cfs):	3.36	9.33	15.85
Subcatchment 2			
PRE DEVELOPMENT RATES (cfs):	4.12	9.33	18.44
POST DEVELOPMENT RATES (cfs):	4.09	8.85	17.01

Table 2.0: Pre-development and Post-development runoff rates.

Standard #3 – Recharge to Groundwater:

At a minimum, the annual recharge from the post-development site approximates the annual recharge from pre-development conditions based on soil type.
For each NRCS Hydrologic Group on the site, the required recharge volume equals the recharge volume set forth multiplied by the total land area within that NRCS Hydrologic Group that is impervious. For the HSG C, the required recharge rate equals:

Impervious area of roadways and sidewalks = 39,204 $ft.^2$

HSG C = 0.25" of runoff x (impervious area)
= 0.25" x (39,204) x 1ft/12"
= 817 $ft.^3$ volume required for recharge

Cultec Unit Volume = 85.97 $ft.^3$ per unit x 10 units = 859.7 $ft.^3$

Conclusion: 859.7 $ft.^3$ provided > 817 $ft.^3$ required - o.k.

Drawdown Analysis: (Basin)
Time $_{drawdown}$ = Rv / (K)(bottom area)
Time $_{drawdown}$ = (85.97 $ft.^3$) (12"/ft.) / (0.27"/hr)(83.33 $ft.^2$)
= 45.85 hours

Conclusion: 45.85 hrs. < 72 hrs - o.k.

Standard #4 – Water Quality:

TSS REMOVAL

Stormwater management systems shall be designed to remove 80% of the average annual post construction load of TSS. Please see attached MaDEP TSS computation sheets for compliance with this removal rate requirement and as reiterated below.

BMP1	% Removal
Deep Sump Hooded catch basins	25%
Stormceptor	80%
Detention basin (with pre-treatment)	50%

TSS Removal = [1.0-(1.0-.25) 1.0-.80)1.0-.50] x 100% = 93%

Conclusion:
Total stormwater system TSS removal = 89%

BMP2	% Removal
Deep Sump Hooded catch basins	25%
Stormceptor	80%

TSS Removal = [1.0-(1.0-.25) 1.0-.80)] x 100% = 85%

Conclusion:
Total stormwater system TSS removal = 85%

WATER QUALITY VOLUME

The required water quality volume equals 0.5" of runoff times the total impervious area of the post-development project site:

Required WQV = 0.5" x Impervious Site Area
(0.5")(39,204 ft.^{2})(1/12) = 1,634 ft.^{3}

The forebay has a capacity of 2,015 ft.^{3} below the weir overflow.

Conclusion: 2,015 ft.^{3} provided = 1,634 ft.^{3} required - o.k.

Sediment Forebay Guidelines:
Site Criteria (MSMP Vol. II):

- An irregular shaped forebay with 12.5"depth and a volume of 2,015 ft.^{3} has been proposed. The contributing impervious area is approximately 39,204 sq. ft (.9 acres). The required sediment forebay size per MSMP standards is 0.1"/impervious acre, or 327 ft.^{3}.

Required Forebay Sizing = 0.1" x Impervious Site Area
(0.1")(39,204 ft.^{2})(1/12) = 327 ft.^{3}

Conclusion: 2,015 ft.^{3} provided > 327 ft.^{3} required - o.k.

Design Criteria (MSMP Vol. II):

- Access can be easily gained to the sediment forebay via the 5:1 maintenance access road, and a 10' wide access berm surrounding the forebay and basin.
- Machinery and hand maintenance can be accommodated.
- The Detention basin and forebay will both work to meet the required recharge volume.
- A floor drain has been proposed in the sediment forebay.
- The sediment forebay depth has been proposed as 12.5".
- Side slopes have been proposed at maximum of 3:1.
- The proposed outlet has been designed to prevent scouring from the 2-year peak discharge.
-

Standard #5 – Higher Potential Pollutant Loads:
This proposal is not a Land Use with Higher Potential Pollutant Load (LUHPPL).

Standard #6 – Protection of Critical Areas:
This site does not have the potential to impact critical areas with sensitive resources as defined in MSMP Vol. I, Ch. 1, page 15.

Standard #7 – Redevelopment Projects:
This site is a not considered a redevelopment project and is subject to full compliance with all Stormwater Management Standards.

Standard #8 – Erosion and Sediment Control:
A plan to control construction related impacts, including erosion, sedimentation, and other pollutant sources during construction and land disturbance activities have been shown on the plans.

This project proposed to disturb more than one acre of land and is required to obtain coverage under the NPDES Construction General Permit issued by EPA and prepare a Stormwater Pollution and Prevention Plan (SWPPP). Submission of the SWPPP to the Local Approving Authority shall occur prior to any land disturbance.

Standard #9 – Operation/Maintenance Plan:

A long-term Operation and Maintenance Plan has been developed and is included in the following appendices. It shall be implemented to ensure that the stormwater systems function as designed.

Standard #10 – Illicit Discharges:

All illicit discharges to the stormwater management system are prohibited. Illicit discharges to the stormwater management system are defined as discharges that are not completely comprised of stormwater. This office has conducted a field inspection of the site. No illicit discharges were detected as part of this inspection. Measures are dictated in the SWPPP to prevent illicit discharges from occurring post-construction.

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

TSS Removal Calculation Worksheet

Location: North Grafton MA

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	0.25	1.00	0.25	0.75
Downstream Defender	0.80	0.75	0.60	0.15
Extended Dry Detention Basin	0.50	0.15	0.08	0.08
	0.00	0.08	0.00	0.08
	0.00	0.08	0.00	0.08

Total TSS Removal = 93%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Abby Woods
Prepared By: ZZW
Date: 2/13/2020

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

TSS Removal Calculation Worksheet

Location: North Grafton, MA

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep Sump & Hooded Catch Basin	0.25	1.00	0.25	0.75
Downstream Defender	0.80	0.75	0.60	0.15
	0	0.15	0	0.15
	0	0.15	0	0.15
	0	0.15	0	0.15

Total TSS Removal = 85%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Abby Woods
Prepared By: LLW
Date: 2/13/2020

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

CULTEC Stormwater and Septic Solutions Since 1986 1-800-4-CULTEC Manufactured at ISO 9001:2000 certified facilities

CULTEC Contactor 100HD Stormwater System Designed for (NAME) (CITY, STATE ZIP)

Required Storage Volume	80 cubic feet

Proposed Design

Number of Rows Wide	2 pieces
Number of Chambers Long	1 pieces
Number of Chambers Required	2 pieces
Bed Width	8.33 feet
Bed Length	10.00 feet
Bed Area Required	83.33 square feet
Volume of Excavation	8 cubic yards
Storage Volume Provided per Installed Chamber	28.81 cubic feet
Storage Provided	85.97 cubic feet ×10 units = 859.7 cf > 817 required

Assumptions

Chamber Height	12.5 inches
Design Unit Height	2.041666667 feet
Chamber Width	36 inches
Chamber Spacing	4 inches
Design Unit Width	3.333333333 feet
Chamber Volume per Linear Foot	1.866 cubic feet / foot
Design Unit Volume	3.841822222 cubic feet / foot
Installed Chamber Length	7.5 feet
Chamber Length Adjustment	0.5 feet

Material List

		Estimated Cost
Contactor 100RHD Starter	2 pieces	#VALUE!
Contactor 100EHD End	0 pieces	#VALUE!
CULTEC No. 410 Filter Fabric	33 square yards	#VALUE!
1 1/2 - 2 inch Diameter Broken Stone	7 tons	#VALUE!
Volume of Excavation	8 cubic yards	#VALUE!
	Total	**#VALUE!**

This is not a quote.

Input the system base elevation in the blue box to customize incremental storage output: **Base Elevation (feet) =** **0**

Click on these links below to go to the product webpages:
CULTEC Contactor 100HD webpage.
CULTEC No. 410 Filter Fabric webpage.

CULTEC, Inc.
P.O. Box 280
Brookfield, CT 06804

Phone: 203-775-4416
Fax: 203-775-1462
www.cultec.com

RIP RAP APRON DESIGN

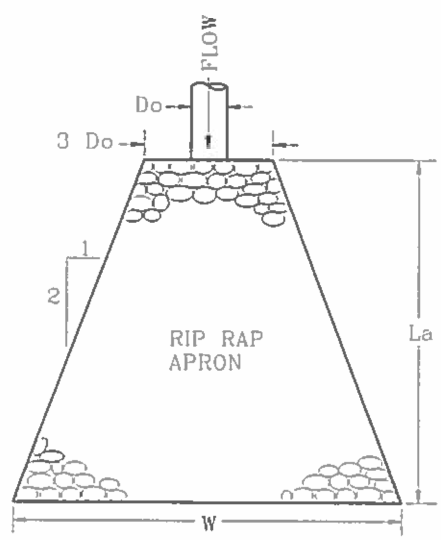
FROM CONNECTICUT GUIDELINES FOR SOIL EROSION AND SEDIMENT CONTROL

FEO-1

GIVEN:	Do =	1.5 ft	
	Q =	10.2 cfs	
	Tw =	0.74 ft	Tw = 49% of Do

FIND:	La =	Length of Rip Rap Pad
	W =	Width of Rip Rap Pad
	d50 =	Average Rock Diameter
	d100 =	Largest Rock Diameter
	T =	Thickness of Rip Rap Pad

La =	(1.7 * Q) / (Do ^(3/2)) + 8 * Do =	21.4 ft		
W =	3 * Do + La =	25.9 ft		
d50 =	(0.02 / Tw) * (Q / Do)^(4 / 3) =	4.2 in	=	3.65 lbs
d100 =	1.5 * (d50) =	6.3 in	=	12.32 lbs
T =	1.5 * (d100) or 6", whichever is greater	6.3 in		



RIP RAP APRON DESIGN

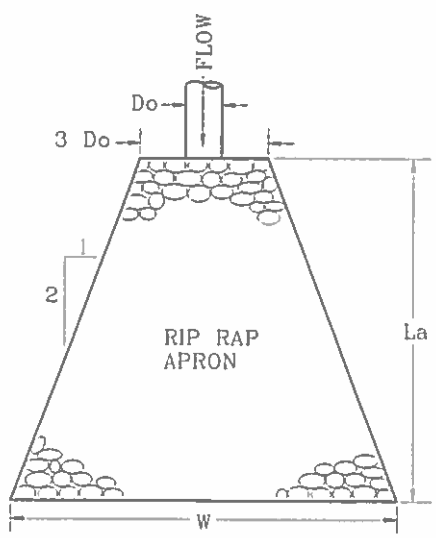
FROM CONNECTICUT GUIDELINES FOR SOIL EROSION AND SEDIMENT CONTROL

FEO-2

GIVEN:	Do =	1.5 ft	
	Q =	14.0 cfs	
	Tw =	0.74 ft	Tw = 49% of Do

FIND:	La =	Length of Rip Rap Pad
	W =	Width of Rip Rap Pad
	d50 =	Average Rock Diameter
	d100 =	Largest Rock Diameter
	T =	Thickness of Rip Rap Pad

La =	(1.7 * Q) / (Do ^(3/2)) + 8 * Do =	25.0 ft		
W =	3 * Do + La =	29.5 ft		
d50 =	(0.02 / Tw) * (Q / Do)^(4 / 3) =	6.4 in	=	13.32 lbs
d100 =	1.5 * (d50) =	9.7 in	=	44.96 lbs
T =	1.5 * (d100) or 6", whichever is greater	6.3 in		



H, S & T Group, Inc.
Professional Land Surveyors & Civil Engineers
75 Hammond Street
Worcester, Massachusetts 01610-1723
Tel: 508-853-9457 508-753-8400 fax: 508-753-8777

DESIGN PERIOD: 25 YEARS
PROJECT: Abby Woods
North Graftonr MA

DATE 4/7/2009
PREPARED LLW
CHECKED ________

LOCATION		ROADWAY			OTHER			Sum	Time	Total		Q				Q	V	Length	Total	Inv.	Inv.	Rim	Rim
From	To	A (ac)	C	CA	A (ac)	C	CA	of CA's	in pipe (min)	Tc (min)	I (in/hr)	I x CA's (cfs)	D (in)	S (ft/ft)	n	Full (cfs)	Full (fps)	of Run (ft)	Fall (ft)	Elev. Upper End	Elev. Lower End	Elev. Upper End	Elev. Lower End
Catch Basins to Detention Pond																							
CB3	DMH5	0.50	0.95	0.48				0.48	0.08	5.00	6.50	3.09	12	0.020	0.013	5.04	6.42	30	0.60	497.74	497.14	501.24	501.49
CB4	DMH5	0.50	0.95	0.48				0.48	0.04	5.00	6.50	3.09	12	0.020	0.013	5.04	6.42	15	0.30	497.74	497.44	501.24	501.49
DMH5	DMH6/SC	—	—	—	—	—	—	0.95	0.28	5.08	6.50	6.18	18	0.005	0.013	7.43	4.20	70	0.35	497.04	496.69	501.49	502.19
DMH6/SC	DMH7	—	—	—	—	—	—	0.95	0.40	5.35	6.44	6.12	18	0.005	0.013	7.43	4.20	100	0.50	496.59	496.09	502.19	504.00
DMH7	POND	—	—	—	—	—	—	0.95	0.41	5.75	6.31	6.00	18	0.005	0.013	7.43	4.20	104	0.52	495.99	495.47	504.00	497.00
Catch Basins to Existing System																							

CULTEC Contactor 100HD Stormwater System Calculations v.2009-072209

PREPARED FOR:

PROJECT INFORMATION:
11-2775.00
Abby Woods
Grafton, MA

CALCULATED BY:
Alicia Messina
Cultec, Inc.
878 Federal Rd
Brookfield, CT
203.775.4416
203.775.1462

DATE: 5/25/11

System Information

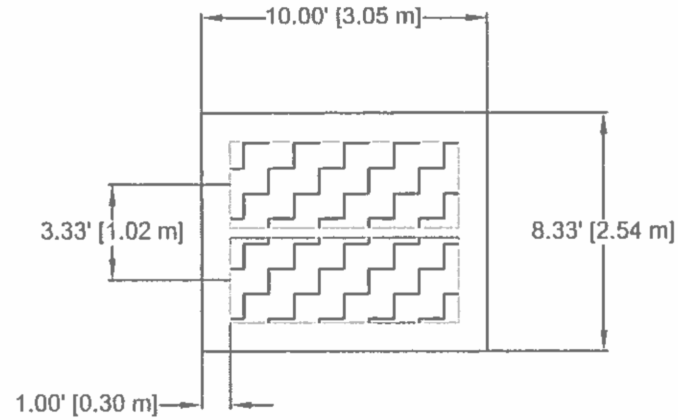
Proposed bed layout of	INPUT	2	Rows x	1	No. of Units per Row

General Given Information

Given:	INPUT		
Storage required	80	CF	2.264 m^3
Stone base	6	inches	152.4 mm
Stone above	6	inches	152.4 mm
Center to Center Spacing	4	inches	101.6 mm
No. of HVLV SFC-24 Feed Connectors	0	units	
Stone Porosity	40	%	
Stone Border Width	1	feet	0.3048 m

Assumptions

Model Name		Chamber Height	Design Unit Height	Chamber Width	Chamber Spacing*	Design Unit Width	Chamber Volume per Linear Foot	Design Unit Volume	Installed Chamber Length
		inches	feet	inches	inches	feet	cu. ft/ft	cu. ft/ft	feet
		mm	m	mm	mm	m	cu. m/m	cu. m/m	m
Contactor® 100 RHD Stand Alone	English	12.5	2.042	36	4	3.333333333	1.8666	3.842	7.500
	Metric	317.5	0.622	914.4	101.6	1.016	0.173	0.357	2.286
HVLV™ SFC-24 Feed Connectors	English	7.6	n/a	12	n/a	n/a	0.32	n/a	0.333
	Metric	193.04	n/a	304.8	n/a	n/a	0.030	n/a	0.102



MATERIALS LIST		
CONTACTOR 100RHD STAND ALONE	2	PIECES
HVLV SFCx2 FEED CONNECTOR	0	PIECES
CULTEC No. 410 FILTER FABRIC 7.5' x 300'	1	ROLLS
CULTEC No. 20L POLYETHYLENE LINER	17	LINEAL FEET
1 1/2 - 2 INCH DIAMETER BROKEN STONE	5	CUBIC YARDS
VOLUME OF EXCAVATION	9	CUBIC YARDS

CULTEC STORMWATER MANAGEMENT SYSTEM
STORAGE REQUIRED: 80 c.f.
STORAGE PROVIDED: 85 c.f.
**INSTALLED USING TYPICAL STONE AMOUNTS OF 6 INCHES BELOW AND ABOVE UNITS AND A 1 FT. BORDER SURROUNDING*

CULTEC, Inc.
Subsurface Stormwater Management Systems
P.O. Box 280
878 Federal Road
Brookfield, CT 06804
www.cultec.com
PH: (203) 775-4416
PH: (800) 4-CULTEC
FX: (203) 775-1462
tech@cultec.com
CULTEC

ABBY WOODS
GRAFTON, MA
PROPOSED STORMWATER SYSTEM

CULTEC CONTACTOR 100HD			
PROJECT NO:	11-2775.00	DATE:	5-25-11
DESIGNED BY:	CULTEC, INC	DRAWN BY:	AMM
SCALE:	N.T.S.	SHEET NO:	1 OF 1

STORAGE PROVIDED WITHIN CULTEC CONTACTOR 100HD STORMWATER CHAMBERS AND HVLV SFC-24 FEED CONNECTORS - not including stone						
Number of Contactor 100 RHD Stand Alone by design			=	2 pcs		
	2	pcs x	7.500	=	15.00 feet	4.572 m
Length adjustment per row			=			
	2	x	0.500	=	1.00 feet	0.3048 m
Number of HVLV SFC-24 Feed Connectors			=	0 pcs		
	0	pcs x	0.333	=	0.00 feet	0 m
Total footage of Contactor 100HD chambers			=	15.00 feet	4.57 m	
Total footage of HVLV SFC-24 Feed Connectors			=	0.00 feet	0.00 m	
Storage provided within Contactor 100HD chambers			=	28.00 CF	0.79 m^3	
Storage within HVLV SFC-24 Feed Connectors			=	0.00 CF	0.00 m^3	
Total Storage within CULTEC 100HD chambers and feed connectors			=	**28.00 CF**	**0.79 m^3**	

STORAGE PROVIDED WITHIN ENTIRE CULTEC STORMWATER SYSTEM - including stone		
Bed width	8.33 feet	2.54 m
Bed length	10.00 feet	3.05 m
Effective Bed depth *(not including additional cover)*	2.04 feet	0.62 m
Total Area	83.33 sq. ft.	7.74 m^2
Volume of Effective Excavation *(not including additional cover)*	170.14 CF	4.82 m^3
Min. Installed Depth *(including min. cover)*	2.71 feet	0.83 m
Perimeter of Bed	36.67 feet	11.18 m
Total Min. Excavation *(including min. cover)*	226 CF	6.39 m^3
Total Storage within CULTEC 150HD chambers and feed connectors	28 CF	0.79 m^3
Total Stone Required	142 CF	4.03 m^3
	5 CY	
	7 tons	
Storage provided within stone	56.86 CF	1.61 m^3
Total Storage within CULTEC Stormwater System =	**85 CF**	**2.40 m^3**

Req. storage attained.

CULTEC MATERIALS LIST

MODEL	Quantity	Unit of Measure		
Recharger 150 RHD Stand Alone Heavy Duty	2	pcs		
CULTEC No. 410 Filter Fabric 7.5' W x 300' L (2.29 m W x 91.44 m L)	1	rolls		
CULTEC No. 20L Polyethylene Liner	17	feet	5	m
Total Stone	7	tons	4	cubic meters

Call CULTEC for cost estimates and system design

This calculator program is for estimation purposes only and should not take the place of a comprehensive engineering design

System calculations do not include materials required conventional pipe manifolds.

The successful application and use of this software product is dependent on the application of skilled engineering judgment supplied by the user and/or their consultant

The user of this software must select input values suitable to describe their specific engineering situation.

The information presented in the computer output is for review, interpretation, application, and approval by a qualified engineer who must assume full responsibility for verifying that all output is appropriate and correct.

Any implied or expressed warranties covering this software program or user manual including warranties of merchantability or fitness for any particular purpose are expressed excluded

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Use of this program constitutes acceptance of this liability agreement by the user

Reconfiguring the bed layout may effect actual storage provided

Contact CULTEC Technical Assistance at 800-428-5832 or 203-775-4416 for further assistance.

Last updated 2009-072209

Calculated by:
CULTEC, Inc.
PO Box 280
Brookfield, CT 06804

PH: 203-775-4416
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www.cultec.com
tech@cultec.com

Technical Information

CULTEC Contactor® 100HD

The Contactor® 100HD is a 12.5" (318 mm) tall, low profile chamber and is typically used for installations with depth restrictions or when a larger infiltrative area is required. The Contactor 100HD has the side portal internal manifold feature. The HVLV™ SFCx2 Feed Connector is inserted into the side portal of the Contactor 100HD to create the internal manifold.

Size (L x W x H)	8' x 36" x 12.5" 2.44 m x 914 mm x 318 mm
Installed Length	7.5' 2.29 m
Length Adjustment per Run	0.5' 0.15 m
Chamber Storage	1.87 ft³/ft 0.17 m³/m 14.00 ft³/unit 0.40 m³/unit
Min. Installed Storage	3.84 ft³/ft 0.36 m³/m 28.81 ft³/unit 0.82 m³/unit
Min. Area Required	25 ft² 2.32 m²
Min. Center to Center Spacing	3.33' 1.02 m
Max. Allowable Cover	14' 4.27 m
Max. Inlet Opening in Endwall	10" 250 mm
Side Portal Dimensions (H x W)	7" x 7.5" 178 mm x 191 mm
Max. Allowable Pipe Size in Side Portal	6" 150 mm
Compatible Feed Connector	HVLV™ SFCx2 Feed Connector

	Stone Foundation Depth		
	6" 152 mm	12" 305 mm	18" 457 mm
Chamber and Stone Storage Per Chamber	28.81 ft³ 0.82 m³	33.81 ft³ 0.96 m³	38.81 ft³ 1.10 m³
Min. Effective Depth	2.04' 0.62 m	2.54' 0.77 m	3.04' 0.93 m
Stone Required Per Chamber	1.37 yd³ 1.05 m³	1.84 yd³ 1.40 m³	2.30 yd³ 1.76 m³

Calculations are based on installed chamber length.
Includes 6" (152 mm) stone above crown of chamber and typical stone surround.
Stone void calculated at 40%.

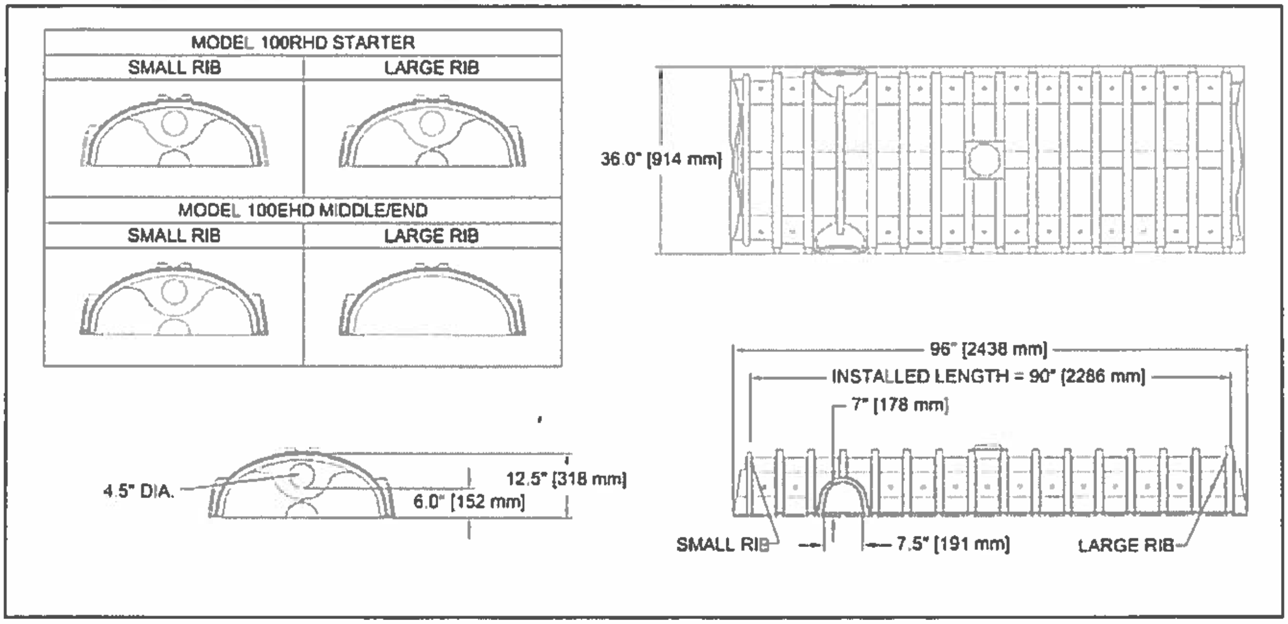
Contactor® 100HD Bare Chamber Storage Volumes

Elevation		Incremental Storage Volume				Cumulative Storage	
in.	mm	ft³/ft	m³/m	ft³	m³	ft³	m³
12	305	0.009	0.001	0.068	0.002	13.995	0.396
11	279	0.067	0.006	0.503	0.014	13.928	0.394
10	254	0.110	0.010	0.825	0.023	13.425	0.380
9	229	0.139	0.013	1.043	0.030	12.600	0.357
8	203	0.159	0.015	1.193	0.034	11.558	0.327
7	178	0.174	0.016	1.305	0.037	10.365	0.294
6	152	0.184	0.017	1.380	0.039	9.060	0.257
5	127	0.192	0.018	1.440	0.041	7.680	0.217
4	102	0.203	0.019	1.523	0.043	6.240	0.177
3	76	0.203	0.019	1.523	0.043	4.718	0.134
2	51	0.203	0.019	1.523	0.043	3.195	0.090
1	25	0.223	0.021	1.673	0.047	1.673	0.047
Total		1.866	0.173	13.995	0.396	13.995	0.396

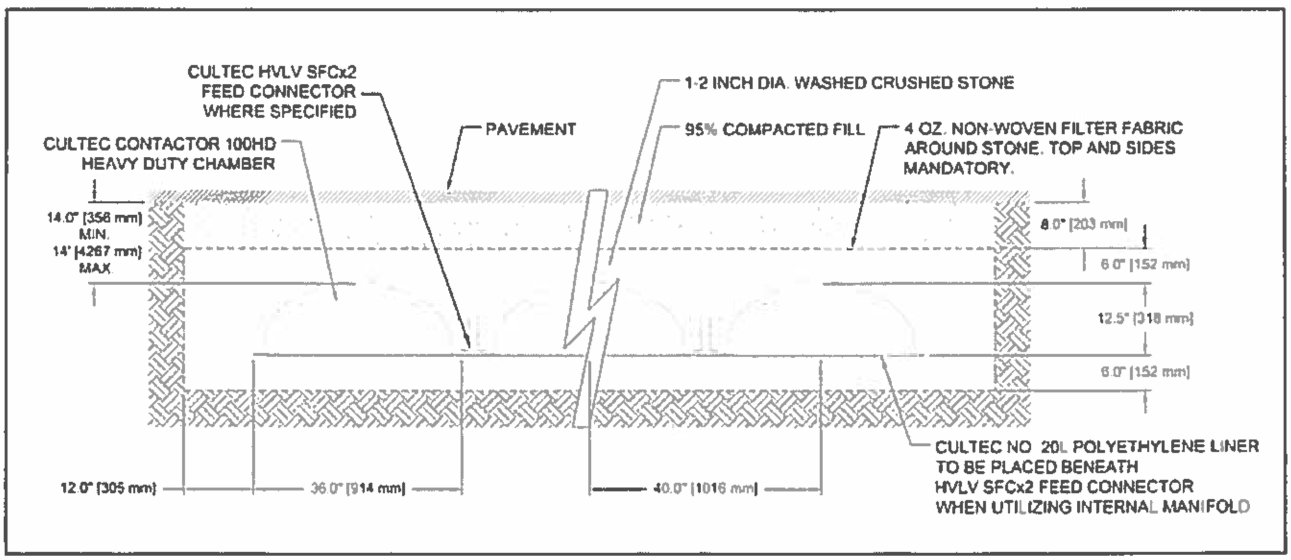
Calculations are based on installed chamber length.

CULTEC Contactor® 100HD

Three View Drawing

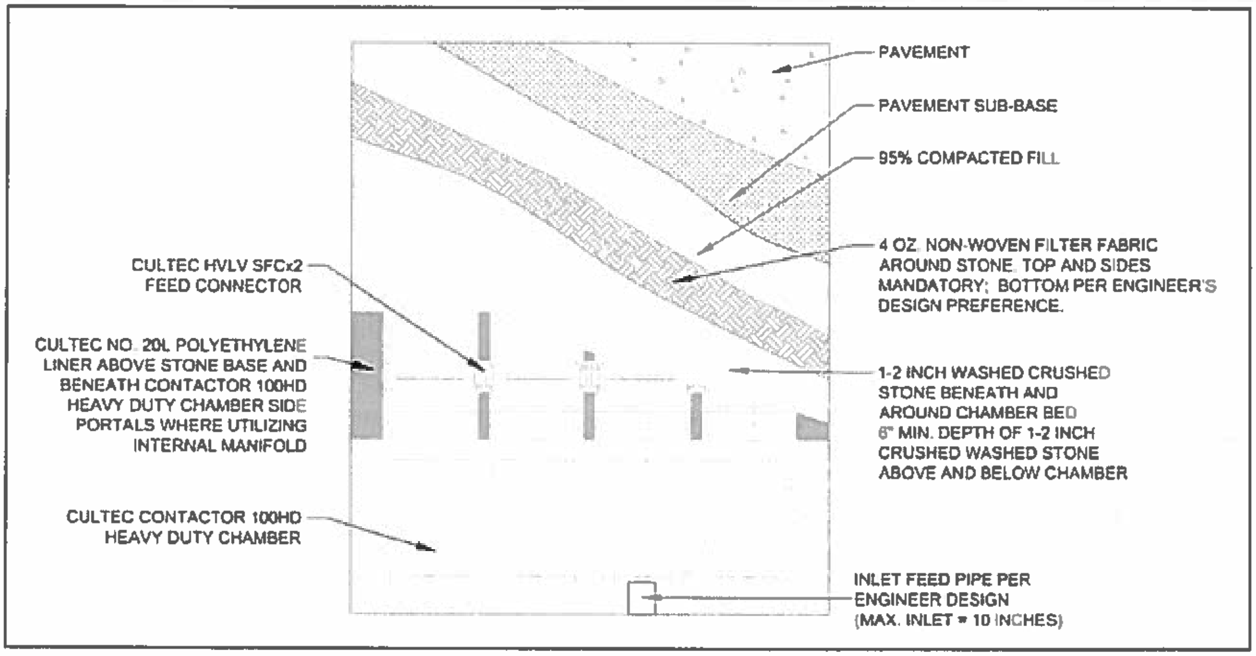


Typical Cross Section for Paved Traffic Application



CULTEC Contactor® 100HD

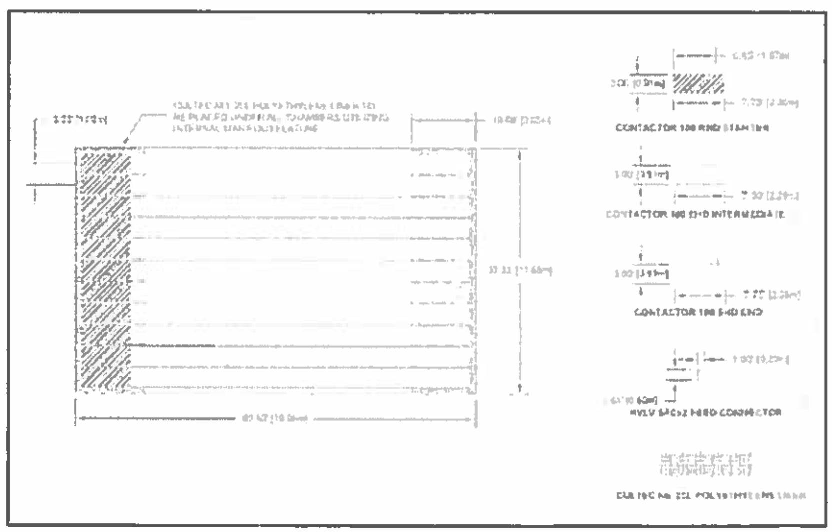
Plan View Drawing



Typical Bed Layout

Using AutoCAD Array Function

1. Add Alternate Units to your Dimension Style and use 0.3048 as the Multiplier
2. Using the Rectangle command, create the three chamber outlines and the feed connectors:
   - Starter: 3.00' x 7.75'
   - Intermediate: 3.00' x 7.5'
   - End: 3.00' x 7.75'
   - Feed Connector: 1.00' x 1.64'
3. Hatch the Starter and End chambers to differentiate them. Place a feed connector (as shown) at one end of the starter and end chambers.
4. Select the Intermediate chamber and select the array command.
5. Specify the number of rows and columns (ex. 10 rows, 7 columns). Do not include the starter and end chambers in the column count.
6. The chambers should be oriented horizontally (as shown). Set the row offset to 3.33' and the column offset to 7.75'. The rotation angle should be 0.
7. Click accept to create the bed.
8. Using the Rectangle command to surround the bed. Offset the rectangle 1' to represent the stone border.
9. Using the Rectangle command create a polyethylene liner underneath the feed connectors at both ends of the bed. It should be 10' wide and span the width of the bed. Apply correct hatching and label the liner.



CULTEC

CULTEC Contactor® 100HD Specifications

GENERAL

CULTEC Contactor® 100HD chambers are designed for underground stormwater management. The chambers may be used for retention, recharging, detention or controlling the flow of on-site stormwater runoff.

CHAMBER PARAMETERS

1. The chambers will be manufactured by CULTEC, Inc. of Brookfield, CT. (203-775-4416 or 1-800-428-5832)
2. The chamber will be vacuum thermoformed of black high molecular weight high density polyethylene (HMWHDPE).
3. The chamber will be arched in shape.
4. The chamber will be open-bottomed.
5. The chamber will be joined using an interlocking overlapping rib method. Connections must be fully shouldered overlapping ribs, having no separate couplings or separate end walls.
6. The nominal chamber dimensions of the CULTEC Contactor® 100HD shall be 12.5 inches (318 mm) tall, 36 inches (914 mm) wide and 8 feet (2.44 m) long. The installed length of a joined Contactor® 100HD shall be 7.5 feet (2.29 m).
7. Maximum inlet opening on the chamber endwall is 10 inches (250 mm).
8. The chamber will have two side portals to accept CULTEC HVLV™ SFCx2 Feed Connectors to create an internal manifold. The nominal dimensions of each side portal will be 7 inches (178 mm) high by 7.5 inches (191 mm) wide. Maximum allowable pipe size in the side portal is 6 inches (150 mm).
9. The nominal chamber dimensions of the CULTEC HVLV™ SFCx2 Feed Connector shall be 7.6 inches (194 mm) tall, 12 inches (305 mm) wide and 19.7 inches (500 mm) long.
10. The nominal storage volume of the Contactor® 100HD chamber will be 1.866 ft^3 / ft (0.173 m^3 / m) - without stone. The nominal storage volume of a joined Contactor® 100HD shall be 13.995 ft^3 / unit (0.396 m^3 / unit) - without stone.
11. The nominal storage volume of the HVLV™ SFCx2 Feed Connector will be 0.294 ft^3 / ft (0.027 m^3 / m) - without stone.
12. The Contactor® 100HD chamber will have fifty-six discharge holes bored into the sidewalls of the unit's core to promote lateral conveyance of water.
13. The Contactor® 100HD chamber shall have 16 corrugations.
14. The endwall of the chamber, when present, will be an integral part of the continuously formed unit. Separate end plates cannot be used with this unit.
15. The Contactor® 100RHD Starter unit must be formed as a whole chamber having two fully formed integral endwalls and having no separate end plates or separate end walls.
16. The Contactor® 100EHD Middle/End unit must be formed as a whole chamber having one fully formed integral endwall and one fully open end wall and having no separate end plates or end walls.
17. The HVLV™ SFCx2 Feed Connector must be formed as a whole chamber having two open end walls and having no separate end plates or separate end walls. The unit will fit into the side portals of the Contactor® 100HD and act as cross feed connections.
18. Chambers must have horizontal stiffening flex reduction steps between the ribs.
19. The chamber will be designed to withstand AASHTO H-25 load rating when installed according to CULTEC's recommended installation instructions.
20. Heavy duty units are designated by a colored stripe formed into the part along the length of the chamber.
21. The chamber will have a raised integral cap at the top of the arch in the center of each unit to be used as an optional inspection port or clean-out.
22. The units may be trimmed to custom lengths by cutting back to any corrugation on the large rib end.
23. The chamber shall be manufactured in an ISO 9001:2000 certified facility.

Stormceptor®

Stormceptor Sizing Detailed Report
PCSWMM for Stormceptor

Project Information

Date	5/31/2011
Project Name	Abby Woods
Project Number	DMH6/SC
Location	North Grafton, MA

Stormwater Quality Objective

This report outlines how Stormceptor System can achieve a defined water quality objective through the removal of total suspended solids (TSS). Attached to this report is the Stormceptor Sizing Summary.

Stormceptor System Recommendation

The Stormceptor System model STC 450i achieves the water quality objective removing 81% TSS for a OK-110 (sand only) particle size distribution.

The Stormceptor System

The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for all rainfall events, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.

Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Stormceptor is the only oil and sediment separator on the market sized to remove TSS for a wide range of particle sizes, including fine sediments (clays and silts), that are often overlooked in the design of other stormwater treatment devices.

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Small storms dominate hydrologic activity, US EPA reports

"Early efforts in stormwater management focused on flood events ranging from the 2-yr to the 100-yr storm. Increasingly stormwater professionals have come to realize that small storms (i.e. < 1 in. rainfall) dominate watershed hydrologic parameters typically associated with water quality management issues and BMP design. These small storms are responsible for most annual urban runoff and groundwater recharge. Likewise, with the exception of eroded sediment, they are responsible for most pollutant washoff from urban surfaces. Therefore, the small storms are of most concern for the stormwater management objectives of ground water recharge, water quality resource protection and thermal impacts control."

"Most rainfall events are much smaller than design storms used for urban drainage models. In any given area, most frequently recurrent rainfall events are small (less than 1 in. of daily rainfall)."

"Continuous simulation offers possibilities for designing and managing BMPs on an individual site-by-site basis that are not provided by other widely used simpler analysis methods. Therefore its application and use should be encouraged."

– US EPA Stormwater Best Management Practice Design Guide, Volume 1 – General Considerations, 2004

Design Methodology

Each Stormceptor system is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology from up-to-date local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective.

The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing (summary of analysis presented in Appendix 2):

- Site parameters
- Continuous historical rainfall, including duration, distribution, peaks (Figure 1)
- Interevent periods
- Particle size distribution
- Particle settling velocities (Stokes Law, corrected for drag)
- TSS load (Figure 2)
- Detention time of the system

The Stormceptor System maintains continuous positive TSS removal for all influent flow rates. Figure 3 illustrates the continuous treatment by Stormceptor throughout the full range of storm events analyzed. It is clear that large events do not significantly impact the average annual TSS removal. There is no decline in cumulative TSS removal, indicating scour does not occur as the flow rate increases.

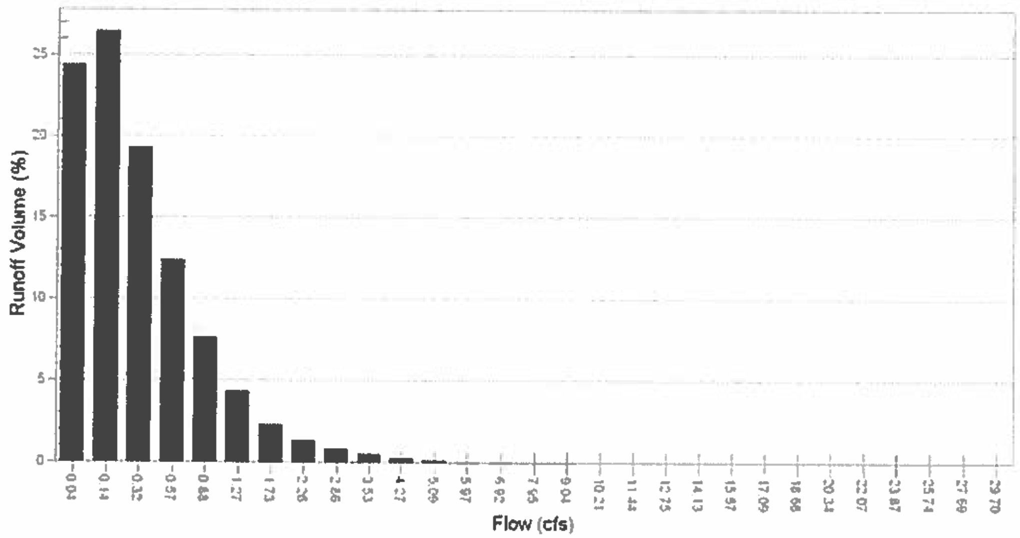

Figure 1. Runoff Volume by Flow Rate for WORCESTER WSO AP – MA 9923, 1948 to 2005 for 1 ac, 100% impervious. Small frequent storm events represent the majority of annual rainfall volume. Large infrequent events have little impact on the average annual TSS removal, as they represent a small percentage of the total annual volume of runoff.

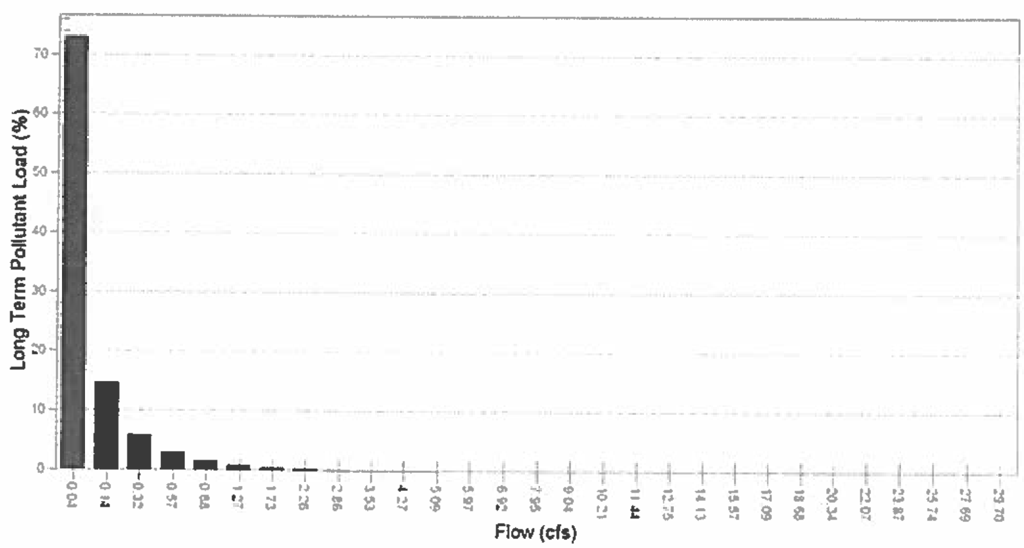

Figure 2. Long Term Pollutant Load by Flow Rate for WORCESTER WSO AP – 9923, 1948 to 2005 for 1 ac, 100% impervious. The majority of the annual pollutant load is transported by small frequent storm events. Conversely, large infrequent events carry an insignificant percentage of the total annual pollutant load.

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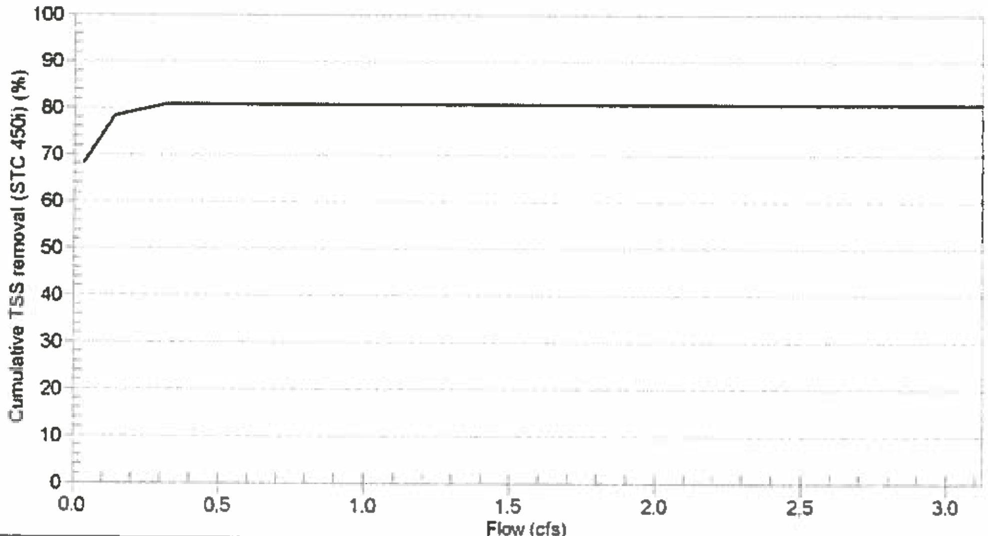

Stormceptor Model	STC 450i	Drainage Area (ac)	1
TSS Removal (%)	81	Impervious (%)	100

Figure 3. Cumulative TSS Removal by Flow Rate for WORCESTER WSO AP – 9923, 1948 to 2005. Stormceptor continuously removes TSS throughout the full range of storm events analyzed. Note that large events do not significantly impact the average annual TSS removal. Therefore no decline in cumulative TSS removal indicates scour does not occur as the flow rate increases.

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Appendix 1
Stormceptor Design Summary

Project Information

Date	5/31/2011
Project Name	Abby Woods
Project Number	DMH6/SC
Location	North Grafton, MA

Designer Information

Company	H S & T Group, Inc
Contact	Lesley Wilson

Notes

N/A

Drainage Area

Total Area (ac)	1
Imperviousness (%)	100

The Stormceptor System model STC 450i achieves the water quality objective removing 81% TSS for a OK-110 (sand only) particle size distribution.

Rainfall

Name	WORCESTER WSO AP
State	MA
ID	9923
Years of Records	1948 to 2005
Latitude	42°16'2"N
Longitude	71°52'34"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	81
STC 900	88
STC 1200	88
STC 1800	88
STC 2400	91
STC 3600	92
STC 4800	94
STC 6000	94
STC 7200	95
STC 11000	97
STC 13000	97
STC 16000	97

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Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

OK-110 (sand only)

Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	0	2.65	0.0012					
53	3	2.65	0.0083					
75	15	2.65	0.0133					
88	25	2.65	0.0180					
106	40.8	2.65	0.0254					
125	15	2.65	0.0343					
150	1	2.65	0.0475					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in.	1 in.	3 in.
Multiple inlet pipes	3 in.	3 in.	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Rinker Materials 1 (800) 909-7763 www.rinkerstormceptor.com

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Appendix 2
Summary of Design Assumptions

SITE DETAILS

Site Drainage Area

Total Area (ac)	1	Imperviousness (%)	100

Surface Characteristics

Width (ft)	417
Slope (%)	2
Impervious Depression Storage (in.)	0.02
Pervious Depression Storage (in.)	0.2
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Maintenance Frequency

Sediment build-up reduces the storage volume for sedimentation. Frequency of maintenance is assumed for TSS removal calculations.

Maintenance Frequency (months)	12

Infiltration Parameters

Horton's equation is used to estimate infiltration

Max. Infiltration Rate (in/hr)	2.44
Min. Infiltration Rate (in/hr)	0.4
Decay Rate (s^{-1})	0.00055
Regeneration Rate (s^{-1})	0.01

Evaporation

Daily Evaporation Rate (inches/day)	0.1

Dry Weather Flow

Dry Weather Flow (cfs)	No

Winter Months

Winter Infiltration	False

Upstream Attenuation

Stage-storage and stage-discharge relationship used to model attenuation upstream of the Stormceptor System is identified in the table below.

Storage ac-ft	Discharge cfs
0	0

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PARTICLE SIZE DISTRIBUTION

Particle Size Distribution

Removing fine particles from runoff ensures the majority of pollutants, such as heavy metals, hydrocarbons, free oils and nutrients are not discharged into natural water resources. The table below identifies the particle size distribution selected to define TSS removal for the design of the Stormceptor System.

OK-110 (sand only)								
Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	0	2.65	0.0012					
53	3	2.65	0.0083					
75	15	2.65	0.0133					
88	25	2.65	0.0180					
106	40.8	2.65	0.0254					
125	15	2.65	0.0343					
150	1	2.65	0.0475					

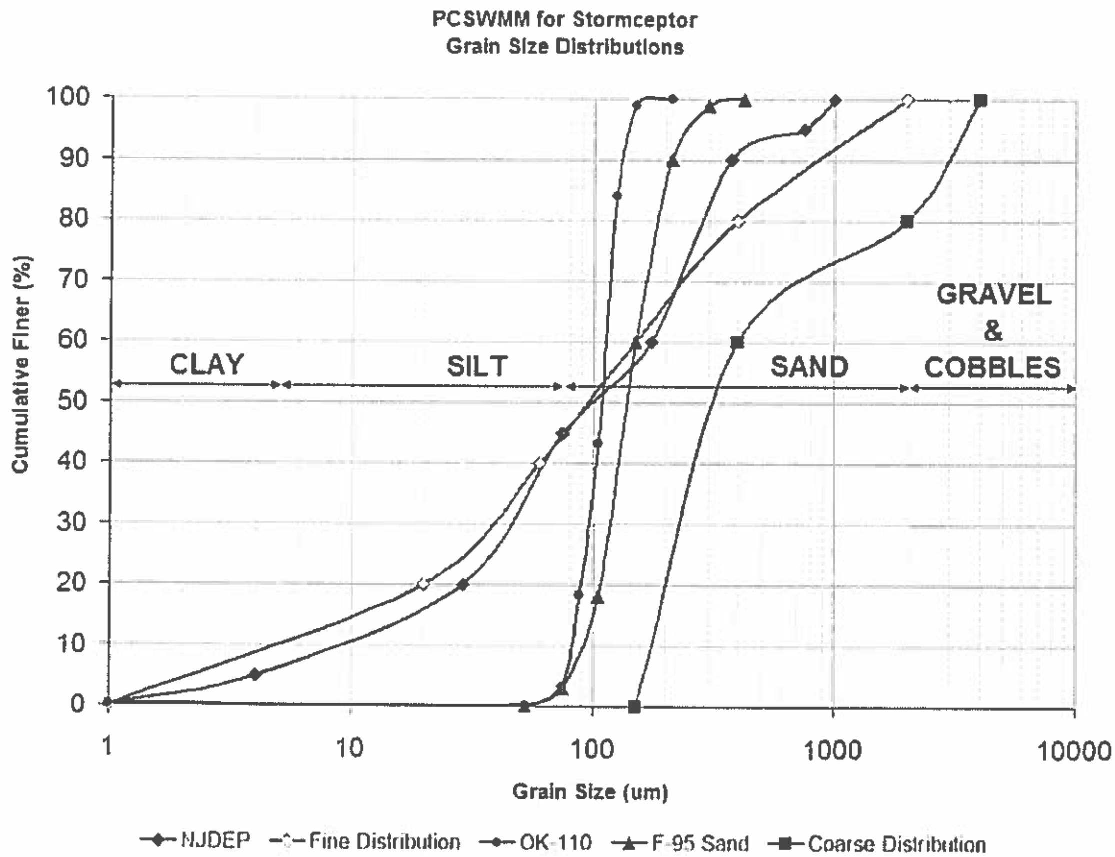

Figure 1. PCSWMM for Stormceptor standard design grain size distributions.

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TSS LOADING

TSS Loading Parameters

TSS Loading Function	Buildup / Washoff

Buildup/Washoff Parameters

Target Event Mean Concentration (EMC) (mg/L)	125
Exponential Buildup Power	0.4
Exponential Washoff Exponential	0.2

TSS Availability Parameters

Availability = $A + Bi^{C}$

Availability Constant A	0.057
Availability Factor B	0.04
Availability Exponent C	1.1
Min. Particle Size Affected by Availability (μm)	400

HYDROLOGY ANALYSIS

PCSWMM for Stormceptor calculates annual hydrology with the US EPA SWMM and local continuous historical rainfall data. Performance calculations of the Stormceptor System are based on the average annual removal of TSS for the selected site parameters. The Stormceptor System is engineered to capture fine particles (silts and sands) by focusing on average annual runoff volume ensuring positive removal efficiency is maintained during all rainfall events, while preventing the opportunity for negative removal efficiency (scour).

Smaller recurring storms account for the majority of rainfall events and average annual runoff volume, as observed in the historical rainfall data analyses presented in this section.

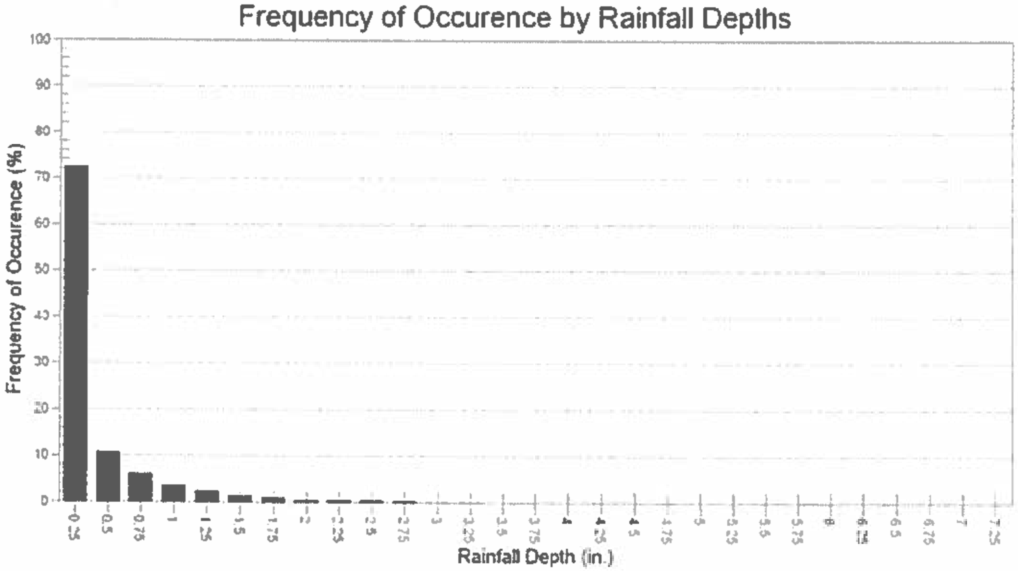
Rainfall Station

Rainfall Station	WORCESTER WSO AP		
Rainfall File Name	MA9923.NDC	Total Number of Events	8087
Latitude	42°16'2"N	Total Rainfall (in.)	2201.4
Longitude	71°52'34"W	Average Annual Rainfall (in.)	38.0
Elevation (ft)	986	Total Evaporation (in.)	210.2
Rainfall Period of Record (y)	58	Total Infiltration (in.)	0.0
Total Rainfall Period (y)	58	Percentage of Rainfall that is Runoff (%)	93.3

Rainfall Event Analysis

Rainfall Depth in.	No. of Events	Percentage of Total Events %	Total Volume in.	Percentage of Annual Volume %
0.25	5853	72.4	350	15.9
0.50	869	10.7	316	14.4
0.75	493	6.1	306	13.9
1.00	290	3.6	255	11.6
1.25	196	2.4	221	10.0
1.50	117	1.4	161	7.3
1.75	81	1.0	131	6.0
2.00	52	0.6	97	4.4
2.25	44	0.5	94	4.3
2.50	30	0.4	71	3.2
2.75	23	0.3	60	2.7
3.00	10	0.1	29	1.3
3.25	10	0.1	31	1.4
3.50	4	0.0	14	0.6
3.75	3	0.0	11	0.5
4.00	3	0.0	12	0.5
4.25	1	0.0	4	0.2
4.50	1	0.0	4	0.2
4.75	2	0.0	9	0.4
5.00	3	0.0	15	0.7
5.25	0	0.0	0	0.0
5.50	1	0.0	5	0.2
5.75	0	0.0	0	0.0
6.00	0	0.0	0	0.0
6.25	1	0.0	6	0.3
6.50	0	0.0	0	0.0
6.75	0	0.0	0	0.0
7.00	0	0.0	0	0.0
7.25	0	0.0	0	0.0
7.50	0	0.0	0	0.0
7.75	0	0.0	0	0.0
8.00	0	0.0	0	0.0
8.25	0	0.0	0	0.0
>8.25	0	0.0	0	0.0

Frequency of Occurence by Rainfall Depths



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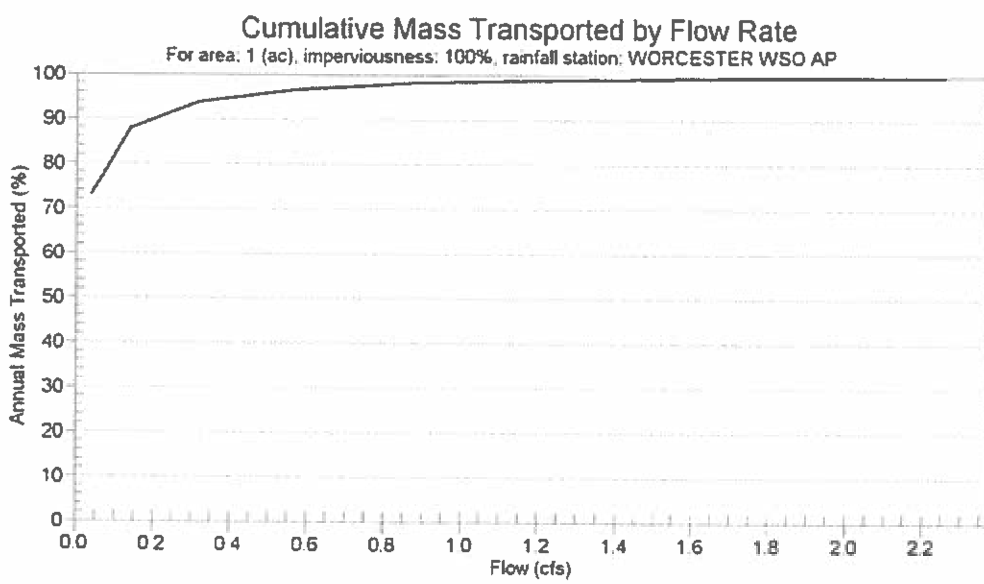
Pollutograph

Flow Rate cfs	Influent Mass ton	Effluent Mass ton	Total Mass ton	Cumulative Mass %
0.035	2.2682	0.836	3.0987	73.2
0.141	2.7247	0.3762	3.0987	87.9
0.318	2.9073	0.1925	3.0987	93.8
0.565	2.9986	0.1012	3.0987	96.7
0.883	3.047	0.0528	3.0987	98.3
1.271	3.0723	0.0275	3.0987	99.1
1.73	3.0855	0.0143	3.0987	99.6
2.26	3.0921	0.0066	3.0987	99.8
2.86	3.0965	0.0033	3.0987	99.9
3.531	3.0976	0.0011	3.0987	100.0
4.273	3.0987	0	3.0987	100.0
5.085	3.0987	0	3.0987	100.0
5.968	3.0987	0	3.0987	100.0
6.922	3.0987	0	3.0987	100.0
7.946	3.0987	0	3.0987	100.0
9.041	3.0987	0	3.0987	100.0
10.206	3.0987	0	3.0987	100.0
11.442	3.0987	0	3.0987	100.0
12.749	3.0987	0	3.0987	100.0
14.126	3.0987	0	3.0987	100.0
15.574	3.0987	0	3.0987	100.0
17.092	3.0987	0	3.0987	100.0
18.681	3.0987	0	3.0987	100.0
20.341	3.0987	0	3.0987	100.0
22.072	3.0987	0	3.0987	100.0
23.873	3.0987	0	3.0987	100.0
25.744	3.0987	0	3.0987	100.0
27.687	3.0987	0	3.0987	100.0
29.7	3.0987	0	3.0987	100.0
31.783	3.0987	0	3.0987	100.0



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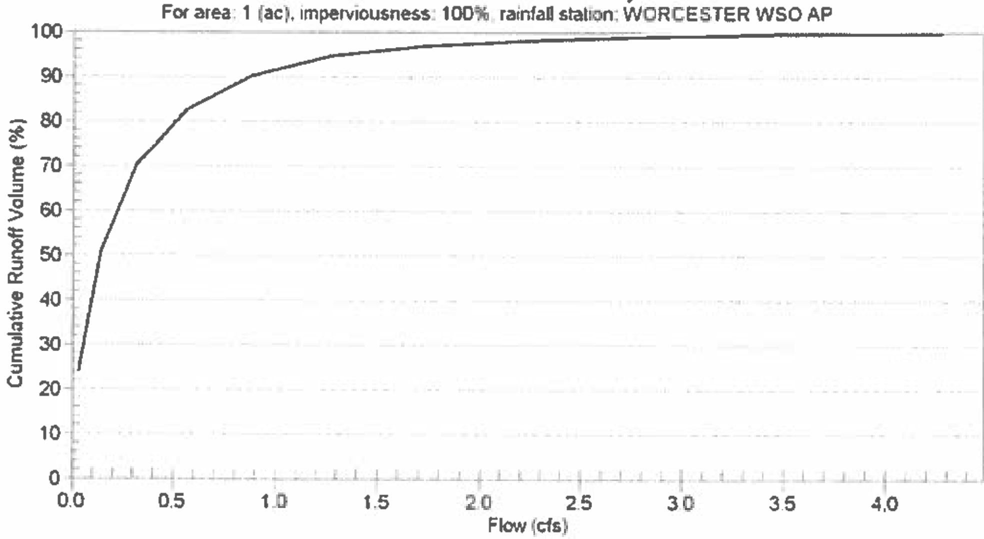
Cumulative Runoff Volume by Runoff Rate

Runoff Rate cfs	Runoff Volume ft³	Volume Overflowed ft³	Cumulative Runoff Volume %
0.035	1820470	5642765	24 4
0.141	3796263	3666020	50.9
0.318	5235818	2226480	70.2
0.565	6161074	1299445	82.6
0 883	6729952	730332	90.2
1.271	7055398	404302	94 6
1.73	7228730	230933	96.9
2.26	7327766	131799	98 2
2.86	7387826	71720	99.0
3.531	7426284	33225	99.6
4.273	7445197	14307	99.8
5.085	7453518	5954	99.9
5.968	7458010	1460	100.0
6.922	7459294	178	100.0
7.946	7459470	0	100.0
9.041	7459470	0	100.0
10.206	7459470	0	100.0
11.442	7459470	0	100.0
12.749	7459470	0	100.0
14.126	7459470	0	100.0
15.574	7459470	0	100.0
17.092	7459470	0	100.0
18.681	7459470	0	100.0
20.341	7459470	0	100.0
22.072	7459470	0	100.0
23.873	7459470	0	100 0
25.744	7459470	0	100.0
27.687	7459470	0	100.0
29.7	7459470	0	100.0
31.783	7459470	0	100.0

Cumulative Volume of Runoff by Runoff Rate

For area: 1 (ac), imperviousness: 100%, rainfall station: WORCESTER WSO AP



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Stormceptor Sizing Detailed Report

PCSWMM for Stormceptor

Project Information

Date	5/31/2011
Project Name	Abby Woods
Project Number	DMH3/SC
Location	North Grafton, MA

Stormwater Quality Objective

This report outlines how Stormceptor System can achieve a defined water quality objective through the removal of total suspended solids (TSS). Attached to this report is the Stormceptor Sizing Summary.

Stormceptor System Recommendation

The Stormceptor System model STC 450i achieves the water quality objective removing 81% TSS for a OK-110 (sand only) particle size distribution.

The Stormceptor System

The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for all rainfall events, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.

Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Stormceptor is the only oil and sediment separator on the market sized to remove TSS for a wide range of particle sizes, including fine sediments (clays and silts), that are often overlooked in the design of other stormwater treatment devices.

Small storms dominate hydrologic activity, US EPA reports

"Early efforts in stormwater management focused on flood events ranging from the 2-yr to the 100-yr storm. Increasingly stormwater professionals have come to realize that small storms (i.e. < 1 in. rainfall) dominate watershed hydrologic parameters typically associated with water quality management issues and BMP design. These small storms are responsible for most annual urban runoff and groundwater recharge. Likewise, with the exception of eroded sediment, they are responsible for most pollutant washoff from urban surfaces. Therefore, the small storms are of most concern for the stormwater management objectives of ground water recharge, water quality resource protection and thermal impacts control."

"Most rainfall events are much smaller than design storms used for urban drainage models. In any given area, most frequently recurrent rainfall events are small (less than 1 in. of daily rainfall)."

"Continuous simulation offers possibilities for designing and managing BMPs on an individual site-by-site basis that are not provided by other widely used simpler analysis methods. Therefore its application and use should be encouraged."

– US EPA Stormwater Best Management Practice Design Guide, Volume 1 – General Considerations, 2004

Design Methodology

Each Stormceptor system is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology from up-to-date local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective.

The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing (summary of analysis presented in Appendix 2):

- Site parameters
- Continuous historical rainfall, including duration, distribution, peaks (Figure 1)
- Interevent periods
- Particle size distribution
- Particle settling velocities (Stokes Law, corrected for drag)
- TSS load (Figure 2)
- Detention time of the system

The Stormceptor System maintains continuous positive TSS removal for all influent flow rates. Figure 3 illustrates the continuous treatment by Stormceptor throughout the full range of storm events analyzed. It is clear that large events do not significantly impact the average annual TSS removal. There is no decline in cumulative TSS removal, indicating scour does not occur as the flow rate increases.

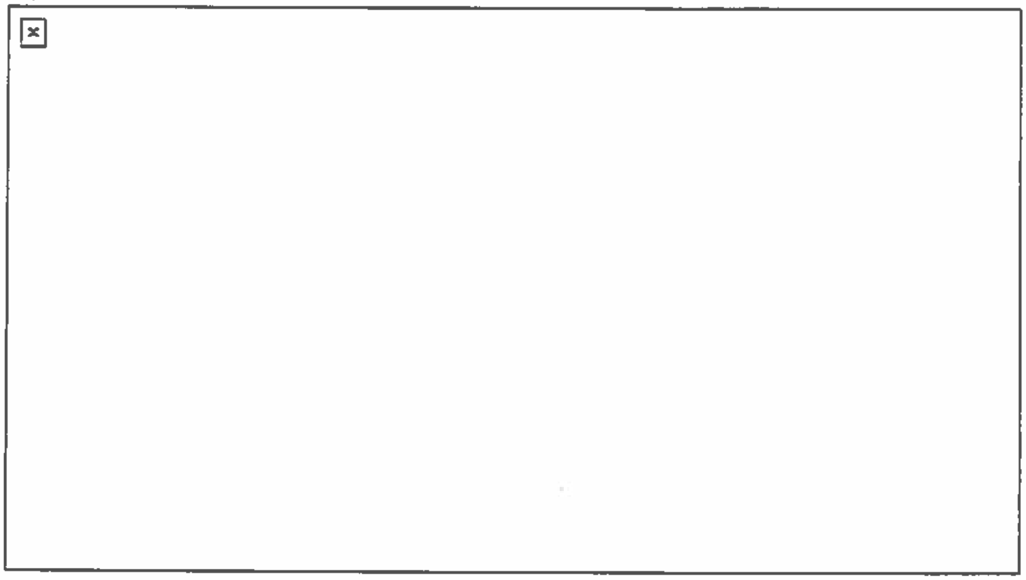

Figure 1. Runoff Volume by Flow Rate for WORCESTER WSO AP – MA 9923, 1948 to 2005 for 1 ac, 100% impervious. Small frequent storm events represent the majority of annual rainfall volume. Large infrequent events have little impact on the average annual TSS removal, as they represent a small percentage of the total annual volume of runoff.

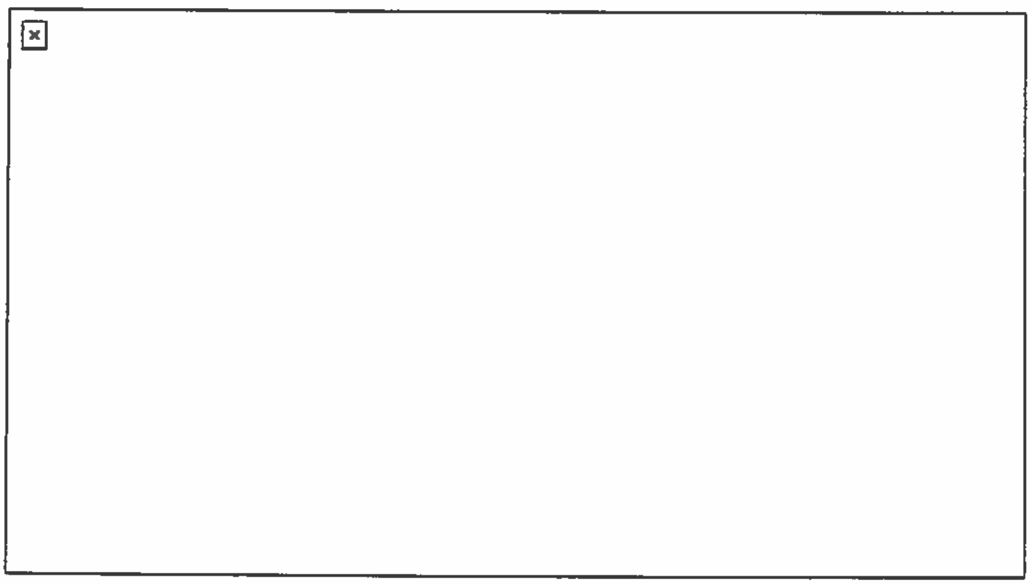

Figure 2. Long Term Pollutant Load by Flow Rate for WORCESTER WSO AP – 9923, 1948 to 2005 for 1 ac, 100% impervious. The majority of the annual pollutant load is transported by small frequent storm events. Conversely, large infrequent events carry an insignificant percentage of the total annual pollutant load.

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Stormceptor Model	STC 450i	Drainage Area (ac)	1
TSS Removal (%)	81	Impervious (%)	100

Figure 3. Cumulative TSS Removal by Flow Rate for WORCESTER WSO AP – 9923, 1948 to 2005. Stormceptor continuously removes TSS throughout the full range of storm events analyzed. Note that large events do not significantly impact the average annual TSS removal. Therefore no decline in cumulative TSS removal indicates scour does not occur as the flow rate increases.

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Appendix 1
Stormceptor Design Summary

Project Information

Date	5/31/2011
Project Name	Abby Woods
Project Number	DMH3/SC
Location	North Grafton, MA

Designer Information

Company	H S & T Group, Inc
Contact	Lesley Wilson

Notes

N/A

Drainage Area

Total Area (ac)	1
Imperviousness (%)	100

The Stormceptor System model STC 450i achieves the water quality objective removing 81% TSS for a OK-110 (sand only) particle size distribution.

Rainfall

Name	WORCESTER WSO AP
State	MA
ID	9923
Years of Records	1948 to 2005
Latitude	42°16'2"N
Longitude	71°52'34"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	81
STC 900	88
STC 1200	88
STC 1800	88
STC 2400	91
STC 3600	92
STC 4800	94
STC 6000	94
STC 7200	95
STC 11000	97
STC 13000	97
STC 16000	97

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Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

OK-110 (sand only)

Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	0	2.65	0.0012					
53	3	2.65	0.0083					
75	15	2.65	0.0133					
88	25	2.65	0.0180					
106	40.8	2.65	0.0254					
125	15	2.65	0.0343					
150	1	2.65	0.0475					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in.	1 in.	3 in.
Multiple inlet pipes	3 in.	3 in.	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Rinker Materials 1 (800) 909-7763 www.rinkerstormceptor.com

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Appendix 2
Summary of Design Assumptions

SITE DETAILS

Site Drainage Area

Total Area (ac)	1	Imperviousness (%)	100

Surface Characteristics

Width (ft)	417
Slope (%)	2
Impervious Depression Storage (in.)	0.02
Pervious Depression Storage (in.)	0.2
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Infiltration Parameters

Horton's equation is used to estimate infiltration

Max. Infiltration Rate (in/hr)	2.44
Min. Infiltration Rate (in/hr)	0.4
Decay Rate (s^{-1})	0.00055
Regeneration Rate (s^{-1})	0.01

Maintenance Frequency

Sediment build-up reduces the storage volume for sedimentation. Frequency of maintenance is assumed for TSS removal calculations.

Maintenance Frequency (months)	12

Evaporation

Daily Evaporation Rate (inches/day)	0.1

Dry Weather Flow

Dry Weather Flow (cfs)	No

Winter Months

Winter Infiltration	False

Upstream Attenuation

Stage-storage and stage-discharge relationship used to model attenuation upstream of the Stormceptor System is identified in the table below.

Storage ac-ft	Discharge cfs
0	0

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PARTICLE SIZE DISTRIBUTION

Particle Size Distribution

Removing fine particles from runoff ensures the majority of pollutants, such as heavy metals, hydrocarbons, free oils and nutrients are not discharged into natural water resources. The table below identifies the particle size distribution selected to define TSS removal for the design of the Stormceptor System.

OK-110 (sand only)

Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	0	2.65	0.0012					
53	3	2.65	0.0083					
75	15	2.65	0.0133					
88	25	2.65	0.0180					
106	40.8	2.65	0.0254					
125	15	2.65	0.0343					
150	1	2.65	0.0475					

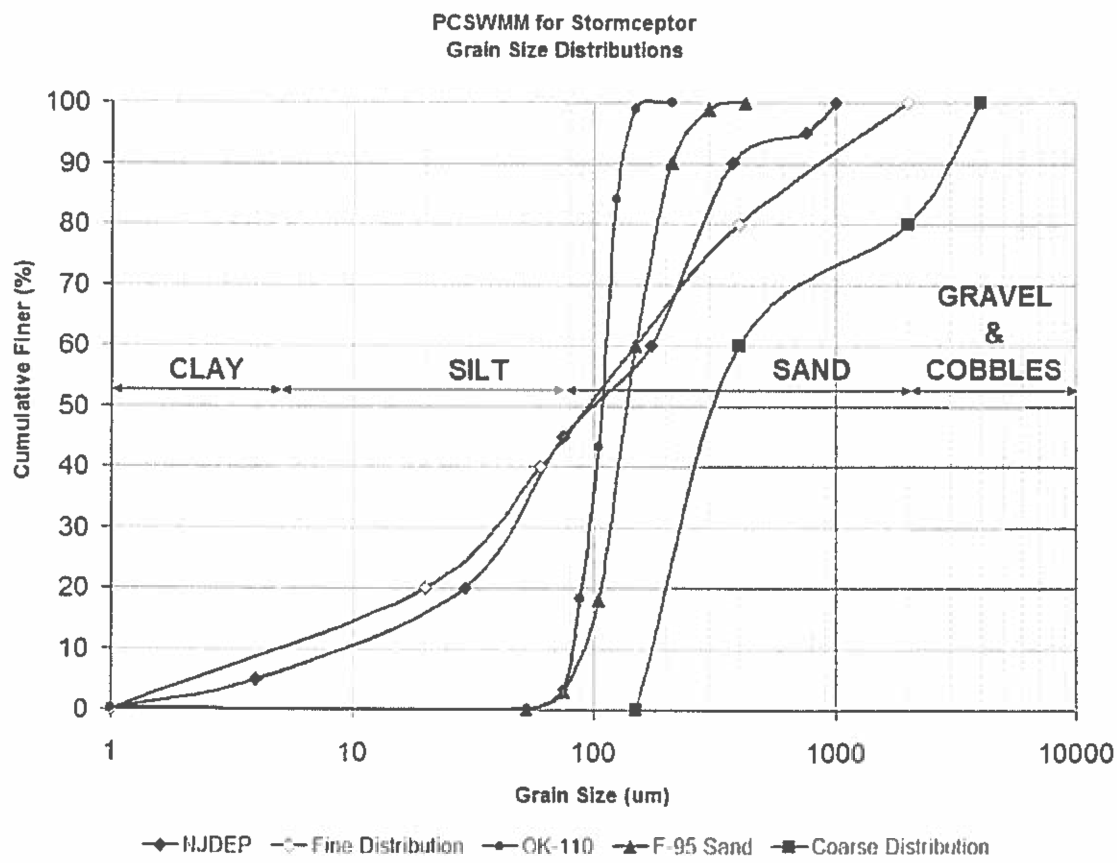

Figure 1. PCSWMM for Stormceptor standard design grain size distributions.

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TSS LOADING

TSS Loading Parameters

TSS Loading Function	Buildup / Washoff

Buildup/Washoff Parameters

Target Event Mean Concentration (EMC) (mg/L)	125
Exponential Buildup Power	0.4
Exponential Washoff Exponential	0.2

TSS Availability Parameters

Availability = A + Bi^C	
Availability Constant A	0.057
Availability Factor B	0.04
Availability Exponent C	1.1
Min. Particle Size Affected by Availability (μm)	400

HYDROLOGY ANALYSIS

PCSWMM for Stormceptor calculates annual hydrology with the US EPA SWMM and local continuous historical rainfall data. Performance calculations of the Stormceptor System are based on the average annual removal of TSS for the selected site parameters. The Stormceptor System is engineered to capture fine particles (silts and sands) by focusing on average annual runoff volume ensuring positive removal efficiency is maintained during all rainfall events, while preventing the opportunity for negative removal efficiency (scour).

Smaller recurring storms account for the majority of rainfall events and average annual runoff volume, as observed in the historical rainfall data analyses presented in this section.

Rainfall Station

Rainfall Station	WORCESTER WSO AP		
Rainfall File Name	MA9923.NDC	Total Number of Events	8087
Latitude	42°16'2"N	Total Rainfall (in.)	2201.4
Longitude	71°52'34"W	Average Annual Rainfall (in.)	38.0
Elevation (ft)	986	Total Evaporation (in.)	210.2
Rainfall Period of Record (y)	58	Total Infiltration (in.)	0.0
Total Rainfall Period (y)	58	Percentage of Rainfall that is Runoff (%)	93.3

Rainfall Event Analysis

Rainfall Depth in.	No. of Events	Percentage of Total Events %	Total Volume in.	Percentage of Annual Volume %
0.25	5853	72.4	350	15.9
0.50	869	10.7	316	14.4
0.75	493	6.1	306	13.9
1.00	290	3.6	255	11.6
1.25	196	2.4	221	10.0
1.50	117	1.4	161	7.3
1.75	81	1.0	131	6.0
2.00	52	0.6	97	4.4
2.25	44	0.5	94	4.3
2.50	30	0.4	71	3.2
2.75	23	0.3	60	2.7
3.00	10	0.1	29	1.3
3.25	10	0.1	31	1.4
3.50	4	0.0	14	0.6
3.75	3	0.0	11	0.5
4.00	3	0.0	12	0.5
4.25	1	0.0	4	0.2
4.50	1	0.0	4	0.2
4.75	2	0.0	9	0.4
5.00	3	0.0	15	0.7
5.25	0	0.0	0	0.0
5.50	1	0.0	5	0.2
5.75	0	0.0	0	0.0
6.00	0	0.0	0	0.0
6.25	1	0.0	6	0.3
6.50	0	0.0	0	0.0
6.75	0	0.0	0	0.0
7.00	0	0.0	0	0.0
7.25	0	0.0	0	0.0
7.50	0	0.0	0	0.0
7.75	0	0.0	0	0.0
8.00	0	0.0	0	0.0
8.25	0	0.0	0	0.0
>8.25	0	0.0	0	0.0

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Pollutograph

Flow Rate cfs	Influent Mass ton	Effluent Mass ton	Total Mass ton	Cumulative Mass %
0.035	2.2682	0.8371	3.0998	73.2
0.141	2.7247	0.3762	3.0998	87.9
0.318	2.9084	0.1925	3.0998	93.8
0.565	2.9986	0.1012	3.0998	96.7
0.883	3.047	0.0528	3.0998	98.3
1.271	3.0723	0.0275	3.0998	99.1
1.73	3.0866	0.0143	3.0998	99.6
2.26	3.0932	0.0066	3.0998	99.8
2.86	3.0965	0.0033	3.0998	99.9
3.531	3.0987	0.0011	3.0998	100.0
4.273	3.0998	0	3.0998	100.0
5.065	3.0998	0	3.0998	100.0
5.968	3.0998	0	3.0998	100.0
6.922	3.0998	0	3.0998	100.0
7.946	3.0998	0	3.0998	100.0
9.041	3.0998	0	3.0998	100.0
10.206	3.0998	0	3.0998	100.0
11.442	3.0998	0	3.0998	100.0
12.749	3.0998	0	3.0998	100.0
14.126	3.0998	0	3.0998	100.0
15.574	3.0998	0	3.0998	100.0
17.092	3.0998	0	3.0998	100.0
18.681	3.0998	0	3.0998	100.0
20.341	3.0998	0	3.0998	100.0
22.072	3.0998	0	3.0998	100.0
23.873	3.0998	0	3.0998	100.0
25.744	3.0998	0	3.0998	100.0
27.687	3.0998	0	3.0998	100.0
29.7	3.0998	0	3.0998	100.0
31.783	3.0998	0	3.0998	100.0

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Cumulative Runoff Volume by Runoff Rate

Runoff Rate cfs	Runoff Volume ft³	Volume Overflowed ft³	Cumulative Runoff Volume %
0.035	1820470	5642765	24.4
0.141	3796263	3666020	50.9
0.318	5235818	2226480	70.2
0.565	6161074	1299445	82.6
0.883	6729952	730332	90.2
1.271	7055398	404302	94.6
1.73	7228730	230933	96.9
2.26	7327766	131799	98.2
2.86	7387826	71720	99.0
3.531	7426284	33225	99.6
4.273	7445197	14307	99.8
5.085	7453518	5954	99.9
5.968	7458010	1460	100.0
6.922	7459294	178	100.0
7.946	7459470	0	100.0
9.041	7459470	0	100.0
10.206	7459470	0	100.0
11.442	7459470	0	100.0
12.749	7459470	0	100.0
14.126	7459470	0	100.0
15.574	7459470	0	100.0
17.092	7459470	0	100.0
18.681	7459470	0	100.0
20.341	7459470	0	100.0
22.072	7459470	0	100.0
23.873	7459470	0	100.0
25.744	7459470	0	100.0
27.687	7459470	0	100.0
29.7	7459470	0	100.0
31.783	7459470	0	100.0

<u>APPENDICIES: Supporting Information Summary</u>

<u>APPENDIX A:</u>
DEP Stormwater Checklist

<u>APPENDIX B:</u>
Drainage System Operation and Maintenance Plan

<u>APPENDIX C:</u>
The 2-year, 10-year, and 100-year, Type III, 24-hour storm events. Rainfall values for each of these return periods have been obtained from the NOAA Atlas 14, Volume 10, Version 3

<u>APPENDIX D:</u>
USDA NRCS Web Soil Survey (WSS)
Various USDA Soil Tables

<u>APPENDIX E:</u>
U.S.G.S. Locus Map

<u>APPENDIX F:</u>
NFIP Firm Community Panel 25027CO829E

<u>APPENDIX G:</u>
Pre-development catchment locations
Post-development catchment locations

<u>APPENDIX H:</u>
Pre-Development Hydrology
Type III, 2-Year 24 Hour Storm
Type III, 10-Year 24 Hour Storm
Type III, 100-Year 24 Hour Storm

<u>APPENDIX I:</u>
Post-Development Hydrology
25-yr Storm Drain Sizing Computations
Type III, 2-Year 24 Hour Storm
Type III, 10-Year 24 Hour Storm
Type III, 100-Year 24 Hour Storm

<u>APPENDIX J:</u>
Soil evaluation results and perc results

APPENDIX A:
DEP Stormwater Checklist

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

COMMONWEALTH OF MASSACHUSETTS
HOSSEIN HAGHANIZADEH
CIVIL
NO. 42529
REGISTERED PROFESSIONAL ENGINEER

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☐ Use of "country drainage" versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☐ Other (describe): ____________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

- ☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
- ☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.
- ☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

- ☐ Soil Analysis provided.
- ☒ Required Recharge Volume calculation provided.
- ☐ Required Recharge volume reduced through use of the LID site Design Credits.
- ☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

  ☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

- ☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.
- ☒ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.
- ☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
- ☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:
  - ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
  - ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
  - ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
  - ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.
- ☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.
- ☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☒ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☒ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☐ is near or to other critical areas

  ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☒ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☐ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☒ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☐ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

APPENDIX B:

Drainage System Operation and Maintenance Plan

ABBY WOODS
NORTH GRAFTON, MASSACHUSETTS

STORMWATER COLLECTION AND TREATMENT SYSTEM

OPERATION AND MAINTENANCE PLAN

This long-term Operation and Maintenance Plan outlines the efforts necessary to ensure that the stormwater collection and treatment system of this site operates in accordance with Massachusetts Department of Environmental Protection Stormwater Management Policy (MSMP) and as designed and approved. In the event that the system performance becomes inadequate, adjustments in the Plan may become necessary to improve the performance.

It is noted that the following restrictions on the use of this property are recommended, for the protection of groundwater:

- Use of salt on road and sidewalk is to be minimized. Under any conditions where sand or other non-toxic materials are suitable, they are to be used.

- Use of pesticides, herbicides and fertilizers should be restricted

- Pet waste should be collected by the owner and disposed of properly.

- Proper storage, use, and disposal of household hazardous chemicals, tires, yard waste, paint and solvents, automobile fluids, and propane tanks is encouraged.

STORMWATER OWNERSHIP AND OPERATION RESPONSIBILITIES

Plan Approval:
Upon approval of the plans, the applicant shall provide a one-time deposit of funds to be placed in escrow with the Town of Grafton. The amount shall be sufficient to cover the estimated cost of maintenance of the basins over a twenty-year period once the subdivision roads have been accepted as public ways and shall be determined on a case-by-case basis.

During Construction:
Construction, maintenance, oversight, and proper operation of the basin and the appurtenant stormwater management system, and construction period erosion and sedimentation controls throughout the construction period shall be the responsibility of the contractor. Until accepted by the Town, the developer shall provide the Planning Board with an annual written report of inspections performed.

Post construction:
The Town of Grafton will obtain responsibility of the inspection and maintenance of the drainage network and facilities upon acceptance of the roads as public ways.

SCHEDULE OF INSPECTIONAND MAINTENANCE TASKS

Onsite Drainage Areas. Areas that drain into the collection system from onsite must be inspected to verify that soil surfaces are stable and that erosion of soils into the collection system is not occurring. In the event that erosion of onsite soils is occurring, the soils must be stabilized against further erosion. Permanently finish the surface against erosion, by placing stable vegetation such as loam and grass seed, or by armoring the surface against erosion with rip-rap placed on a filter fabric blanket.

Asphalt Surfaces. Inspect asphalt surfaces for accumulation of sand, litter, eroded soils or other deleterious materials. Verify that no hazardous materials, such as fuel oil, motor oils or other material has occurred. Pick up all litter, junk, trash, or any other deleterious materials left on the surface. Upon detecting accumulation of sand, sediment or other materials, the asphalt surface must be swept to remove all such materials. All sweepings collected must be disposed of in accordance with current Massachusetts Department of Environmental Protection standards for such waste disposal. Any material deposits deemed to be hazardous must be removed and disposed of by a licensed contractor.

Deep Sump Catch Basins. Inspect units four times per year. Clean units four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. One study found that once 50% of the sump volume is filled, the catch basin is not able to retain additional sediments. Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow removal seasons. Sediments must also be removed four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. If handling runoff from land uses with higher potential pollutant loads or discharging runoff near or to a critical area, more frequent cleaning may be necessary. Clamshell buckets are typically used to remove sediment, however, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Sediment Trap (Forebay). Inspect sediment forebays monthly. Clean sediment forebays four times per year and when sediment is between 3-6 feet deep. At a minimum, inspect sediment forebays monthly and clean them out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational, otherwise the practice will discharge excess amounts of suspended sediments. When mowing grasses, keep the grass height no greater than 6 inches. Set mower blades no lower than 3 to 4 inches. Check for signs of rilling and gullying and repair as needed. After removing the sediment, replace any vegetation damaged during the clean-out by either reseeding or resodding. When reseeding, incorporate practices such as hydroseeding with a tackifier, blanket, or similar practice to ensure that no scour occurs in the forebay, while the seeds germinate and develop roots.

Detention Basin. Conduct preventative maintenance twice per year. Inspect to ensure proper functioning after every major storm during first 3 months of operation and twice a year thereafter and when there are discharges through the high outlet orifice. Mow the buffer area, side slopes, and basin bottom if grassed floor; rake if stone bottom; remove trash and debris; remove grass clippings and accumulated organic matter twice a year. The inspection must require inspecting the pretreatment BMPs in accordance with the minimal requirements specified for those practices and after every major storm event. A major storm event is defined as a storm that is equal to or greater than the 2-year, 24-hour storm (generally 2.9 to 3.6 inches in a 24-hour period, depending in geographic location in Massachusetts). Once the basin is in use, inspect it after every major storm for the first few months to ensure it is stabilized and functioning properly and if necessary take corrective action. Note how long water remains standing in the basin after a storm; standing water within the basin 48 to 72 hours after a storm indicates that the infiltration capacity may have been overestimated. If the ponding is due to clogging, immediately address the reasons for the clogging (such as upland sediment erosion, excessive compaction of soils, or low spots). Thereafter, inspect the Detention basin at least twice per year. Important items to check during the inspection include: Signs of differential settlement, Cracking, Erosion, Leakage in the embankments, Tree growth on the embankments , Condition of riprap, Sediment accumulation and, The health of the turf.

At least twice a year, mow the buffer area, side slopes, and basin bottom. Remove grass clippings and accumulated organic matter to prevent an impervious organic mat from forming. Remove trash and debris at the same time. Use deep tilling to break up clogged surfaces, and revegetate immediately. Remove sediment from the basin as necessary, but wait until the floor of the basin is thoroughly dry. Use light equipment to remove the top layer so as to not compact the underlying soil. Deeply till the remaining soil, and revegetate as soon as possible. Inspect and clean pretreatment devices associated with basins

Downstream Defenders. Inspect the unit monthly and within 24 hours after a storm with rainfall of 0.1" or greater. Sediment and oil shall be removed when the storage volume is reduced by one half, or at least every 6 months (refer to the manufacturers recommendations for maintenance requirements)

RECORDKEEPING

It is necessary that record of each inspection and maintenance activity be kept. The record keeping shall be kept on the O&M Maintenance Log for issued by DEP. Such information should include the following:

- Person Performing the activity
- The date of the activity, and the weather conditions
- The preceding weather conditions
- The site conditions (dry, heavy snow cover, saturated conditions, etc.)
- The specific activity (inspection, cleaning, etc)
- The facility inspected
- The conditions of the facility
- The results of the activity

Illicit Discharge Compliance Statement

This statement is to document that there are no and will be no Illicit Discharges for the Proposed site located at Carroll Road. Grafton MA

____
Lesley Wilson

____
Date

APPENDIX C:

2-year, 10-year, and 100-year, Type III, 24-hour storm events. Rainfall values for each of these return periods have been obtained from the NOAA Atlas 14, Volume 10, Version 3

NOAA Atlas 14, Volume 10, Version 3
Location name: North Grafton, Massachusetts, USA*
Latitude: 42.2199°, Longitude: -71.6877°
Elevation: 363.1 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.341 (0.266-0.434)	0.405 (0.315-0.516)	0.510 (0.396-0.652)	0.597 (0.460-0.768)	0.716 (0.535-0.962)	0.806 (0.590-1.11)	0.900 (0.639-1.28)	1.00 (0.676-1.47)	1.15 (0.746-1.75)	1.27 (0.802-1.96)
10-min	0.483 (0.376-0.614)	0.573 (0.447-0.730)	0.721 (0.559-0.922)	0.844 (0.652-1.09)	1.01 (0.757-1.36)	1.14 (0.835-1.57)	1.27 (0.905-1.82)	1.42 (0.959-2.08)	1.63 (1.06-2.47)	1.80 (1.14-2.78)
15-min	0.568 (0.443-0.723)	0.675 (0.525-0.859)	0.849 (0.659-1.09)	0.994 (0.767-1.28)	1.19 (0.891-1.60)	1.34 (0.983-1.84)	1.50 (1.06-2.14)	1.67 (1.13-2.45)	1.92 (1.24-2.91)	2.11 (1.34-3.27)
30-min	0.773 (0.603-0.984)	0.919 (0.716-1.17)	1.16 (0.898-1.48)	1.36 (1.05-1.74)	1.63 (1.22-2.19)	1.83 (1.34-2.52)	2.05 (1.45-2.92)	2.28 (1.54-3.34)	2.61 (1.70-3.97)	2.88 (1.82-4.47)
60-min	0.978 (0.763-1.25)	1.16 (0.906-1.48)	1.47 (1.14-1.87)	1.72 (1.33-2.21)	2.06 (1.54-2.77)	2.32 (1.70-3.19)	2.59 (1.84-3.70)	2.89 (1.95-4.23)	3.31 (2.15-5.03)	3.65 (2.31-5.66)
2-hr	1.24 (0.969-1.57)	1.48 (1.16-1.88)	1.88 (1.47-2.39)	2.21 (1.71-2.82)	2.66 (2.00-3.57)	3.00 (2.21-4.11)	3.36 (2.41-4.79)	3.78 (2.55-5.50)	4.39 (2.85-6.62)	4.90 (3.11-7.55)
3-hr	1.42 (1.11-1.79)	1.70 (1.34-2.15)	2.17 (1.70-2.75)	2.55 (1.99-3.26)	3.08 (2.33-4.13)	3.48 (2.57-4.76)	3.90 (2.81-5.57)	4.40 (2.98-6.39)	5.15 (3.35-7.75)	5.78 (3.68-8.87)
6-hr	1.79 (1.42-2.25)	2.16 (1.71-2.72)	2.77 (2.18-3.49)	3.27 (2.56-4.15)	3.96 (3.01-5.28)	4.47 (3.33-6.10)	5.03 (3.65-7.15)	5.69 (3.87-8.21)	6.70 (4.38-10.0)	7.56 (4.82-11.5)
12-hr	2.25 (1.79-2.81)	2.72 (2.16-3.40)	3.50 (2.77-4.39)	4.15 (3.26-5.23)	5.03 (3.84-6.67)	5.69 (4.26-7.72)	6.40 (4.66-9.05)	7.25 (4.95-10.4)	8.54 (5.60-12.7)	9.64 (6.17-14.6)
24-hr	2.68 (2.14-3.32)	3.27 (2.61-4.06)	4.23 (3.37-5.28)	5.04 (3.98-6.32)	6.14 (4.71-8.09)	6.96 (5.23-9.39)	7.84 (5.74-11.0)	8.91 (6.10-12.7)	10.5 (6.93-15.6)	11.9 (7.67-18.0)
2-day	3.03 (2.44-3.74)	3.73 (3.00-4.61)	4.88 (3.91-6.06)	5.83 (4.64-7.28)	7.14 (5.51-9.38)	8.11 (6.14-10.9)	9.17 (6.76-12.9)	10.5 (7.19-14.8)	12.5 (8.24-18.3)	14.2 (9.17-21.3)
3-day	3.29 (2.66-4.05)	4.05 (3.26-4.99)	5.29 (4.25-6.54)	6.32 (5.04-7.85)	7.73 (5.98-10.1)	8.77 (6.65-11.8)	9.91 (7.33-13.9)	11.3 (7.79-16.0)	13.5 (8.92-19.7)	15.4 (9.93-22.9)
4-day	3.54 (2.86-4.35)	4.33 (3.50-5.33)	5.63 (4.53-6.94)	6.70 (5.36-8.31)	8.18 (6.34-10.7)	9.27 (7.04-12.4)	10.5 (7.74-14.6)	11.9 (8.22-16.8)	14.2 (9.38-20.7)	16.1 (10.4-23.9)
7-day	4.23 (3.44-5.17)	5.08 (4.13-6.22)	6.48 (5.24-7.97)	7.64 (6.14-9.44)	9.24 (7.18-12.0)	10.4 (7.94-13.8)	11.7 (8.66-16.2)	13.2 (9.16-18.5)	15.5 (10.3-22.5)	17.5 (11.3-25.9)
10-day	4.90 (3.99-5.98)	5.79 (4.71-7.07)	7.25 (5.88-8.88)	8.46 (6.81-10.4)	10.1 (7.88-13.0)	11.4 (8.65-15.0)	12.7 (9.36-17.4)	14.2 (9.86-19.8)	16.5 (11.0-23.8)	18.4 (11.9-27.1)
20-day	6.96 (5.70-8.44)	7.90 (6.46-9.59)	9.44 (7.69-11.5)	10.7 (8.68-13.1)	12.5 (9.74-15.9)	13.8 (10.5-17.9)	15.2 (11.2-20.4)	16.6 (11.6-23.0)	18.7 (12.5-26.7)	20.2 (13.2-29.6)
30-day	8.67 (7.13-10.5)	9.64 (7.92-11.7)	11.2 (9.19-13.6)	12.5 (10.2-15.3)	14.4 (11.2-18.2)	15.8 (12.0-20.3)	17.2 (12.6-22.8)	18.5 (13.0-25.5)	20.3 (13.6-29.0)	21.7 (14.1-31.5)
45-day	10.8 (8.91-13.0)	11.8 (9.73-14.2)	13.5 (11.0-16.3)	14.8 (12.1-18.0)	16.7 (13.1-21.0)	18.2 (13.9-23.3)	19.6 (14.4-25.8)	20.9 (14.7-28.6)	22.5 (15.1-31.9)	23.6 (15.4-34.2)
60-day	12.6 (10.4-15.1)	13.6 (11.3-16.4)	15.3 (12.6-18.5)	16.8 (13.7-20.3)	18.7 (14.7-23.4)	20.3 (15.5-25.8)	21.7 (15.9-28.3)	23.0 (16.2-31.3)	24.4 (16.5-34.5)	25.4 (16.6-36.6)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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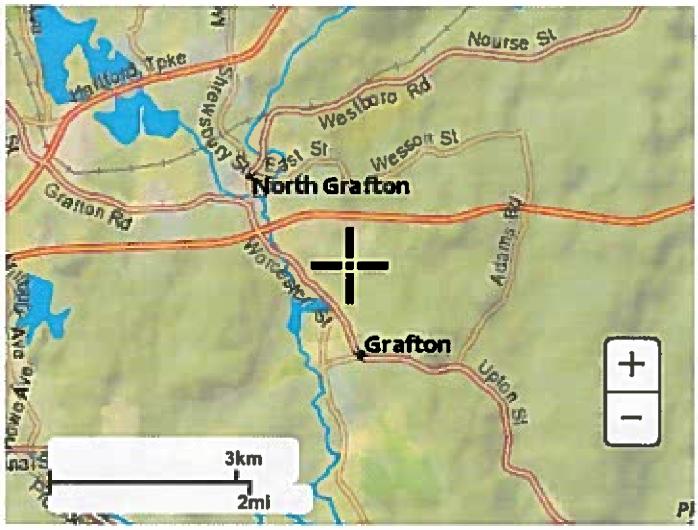
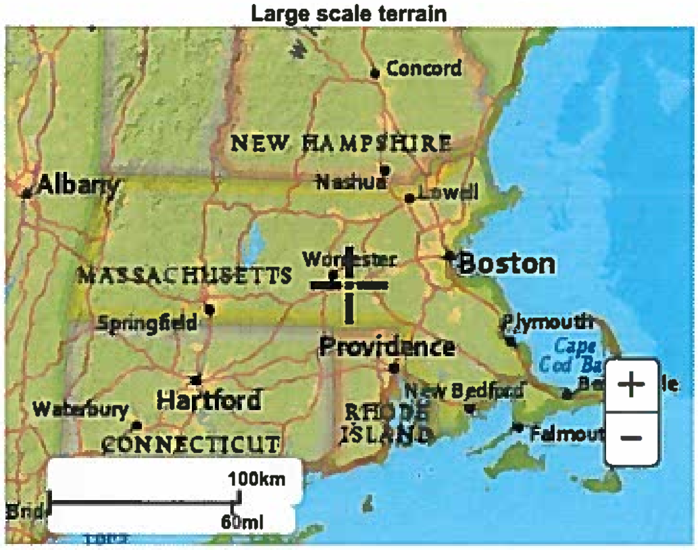
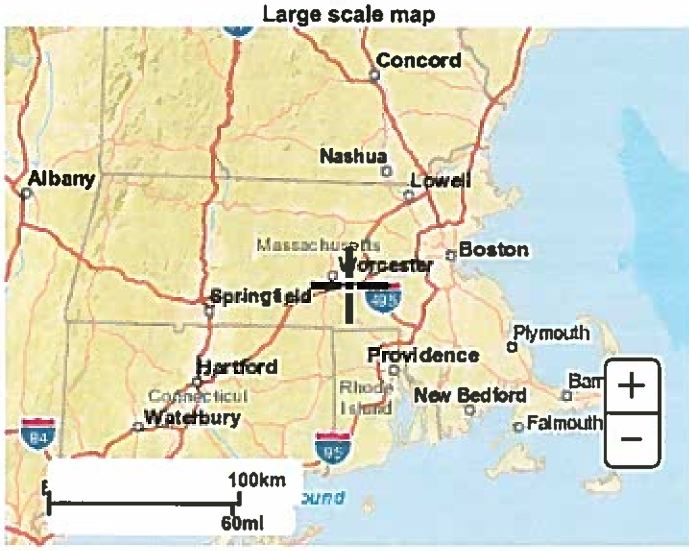


Large scale terrain



Large scale map

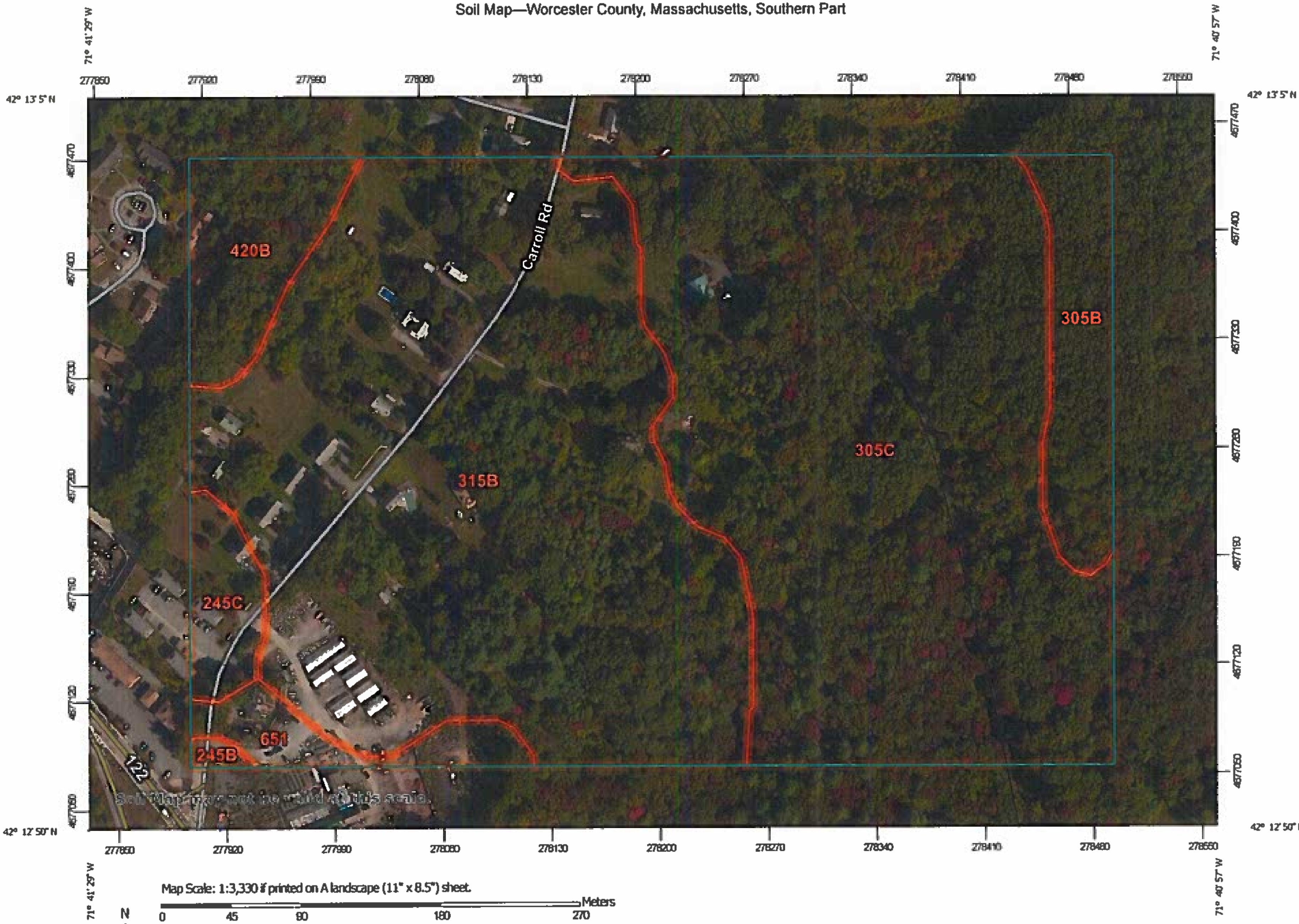


Large scale aerial

APPENDIX D:

USDA NCRS Web Soil Survey
Various USDA Soil Tables

Soil Map—Worcester County, Massachusetts, Southern Part



Map Scale: 1:3,330 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 45, 90, 180, 270

Feet: 0, 150, 300, 600, 900

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 12, Sep 12, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 12, 2014—Sep 28, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
245B	Hinckley loamy sand, 3 to 8 percent slopes	0.2	0.3%
245C	Hinckley loamy sand, 8 to 15 percent slopes	1.3	2.3%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	2.8	4.9%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	24.0	41.3%
315B	Scituate fine sandy loam, 3 to 8 percent slopes	25.8	44.4%
420B	Canton fine sandy loam, 3 to 8 percent slopes	2.6	4.5%
651	Udorthents, smoothed	1.4	2.4%
Totals for Area of Interest		**58.2**	**100.0%**


420B
Carroll Rd
305B
305C
315B
245C
651
245B
Ramp
0
300 ft

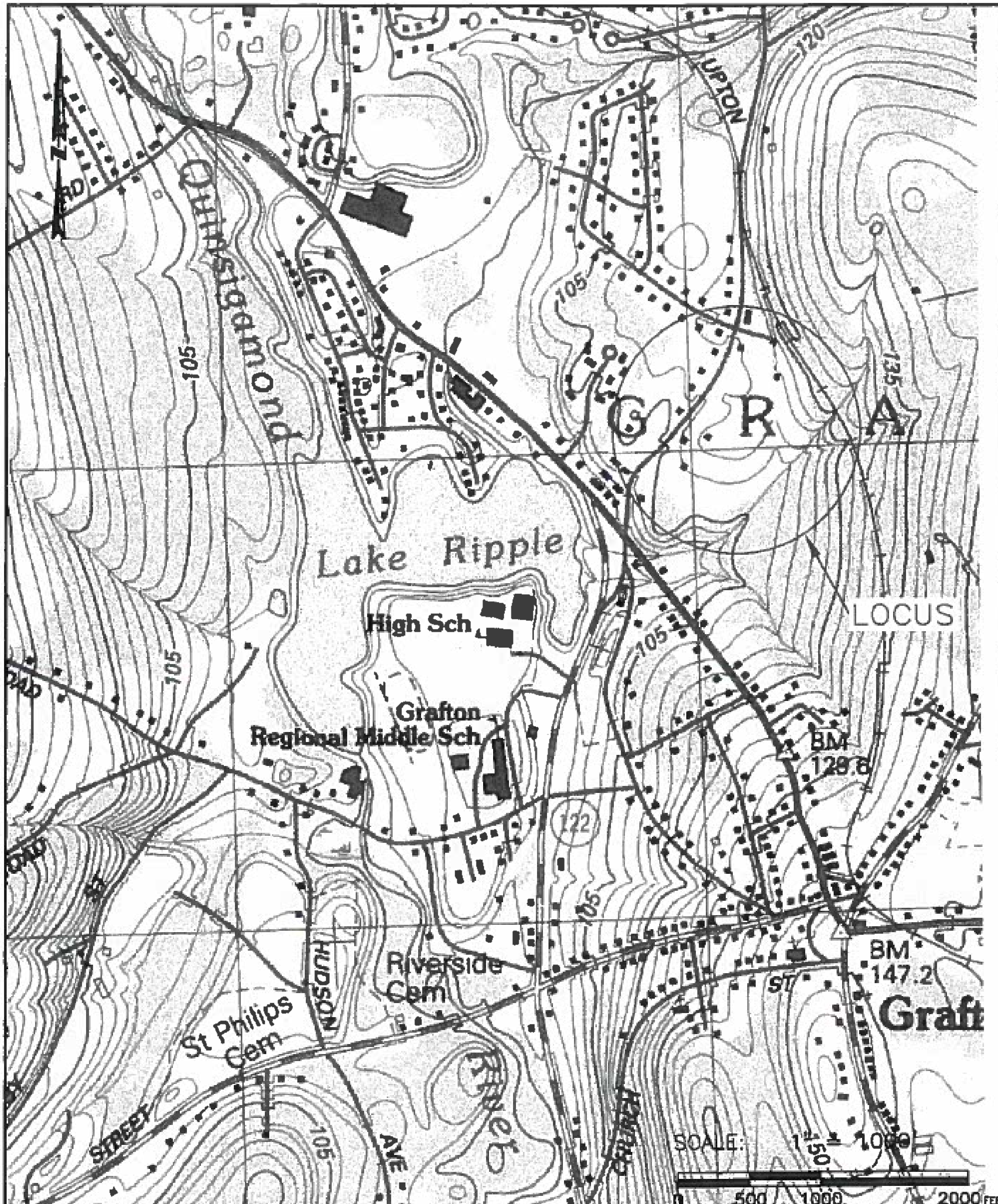
Tables — Hydrologic Soil Group — Summary By Map Unit

Summary by Map Unit — Worcester County, Massachusetts, Southern Part (MA615)

Summary by Map Unit — Worcester County, Massachusetts, Southern Part (MA615)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
245B	Hinckley loamy sand, 3 to 8 percent slopes	A	0.2	0.3%
245C	Hinckley loamy sand, 8 to 15 percent slopes	A	1.3	2.3%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	C	2.8	4.9%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	C	24.0	41.3%
315B	Scituate fine sandy loam, 3 to 8 percent slopes	C	25.8	44.4%
420B	Canton fine sandy loam, 3 to 8 percent slopes	B	2.6	4.5%
651	Udorthents, smoothed	A	1.4	2.4%
Totals for Area of Interest			**58.2**	**100.0%**

APPENDIX E:
U.S.G.S. Locus Map



PREPARED FOR:	SITE LOCUS MAP	hs&t group, inc. PROFESSIONAL CIVIL ENGINEERS & LAND SURVEYORS 75 HAMMOND STREET - 2ND FLOOR WORCESTER, MASSACHUSETTS 01610-1723 PHONE: 508-757-4944 EMAIL: INFO@HSTGROUP.NET FAX: 508-752-8895 WWW.HSTGROUP.NET
PROTEC BUILDERS 130 GULF STREET SHREWSBURY MA 01545	ABBY WOODS WORCESTER, MA	Job No.: 2650 Date: 12/13/20 Scale: 1"=1000' Revised: Dwg. No: Figure: 1

File: LOCUS.DWG

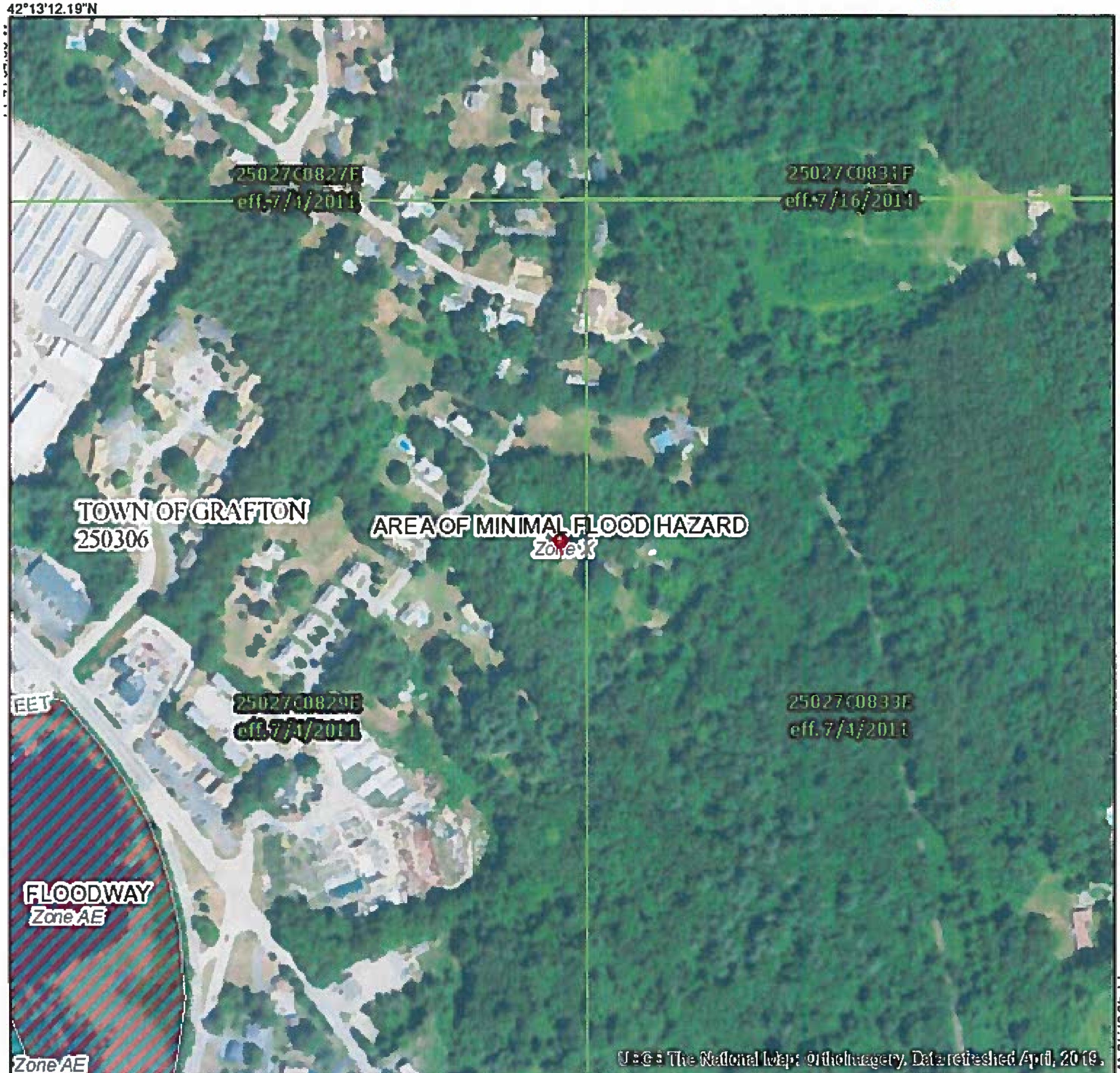
APPENDIX F:

NFIP Firm Community Panel 25027CO829E

National Flood Hazard Layer FIRMette

FEMA

42°13'12.19"N



71°40'57.18"W

42°12'45.54"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

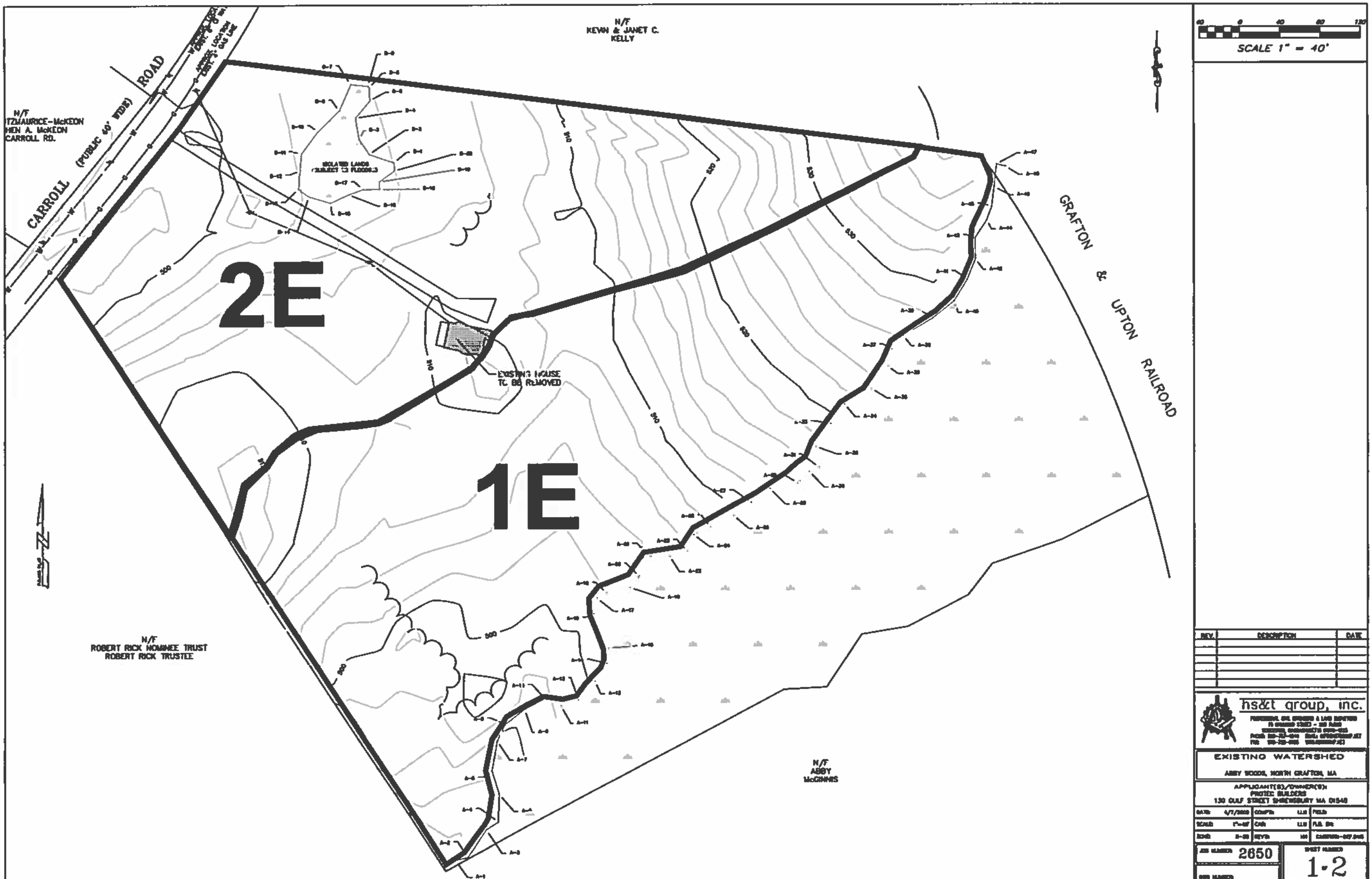
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

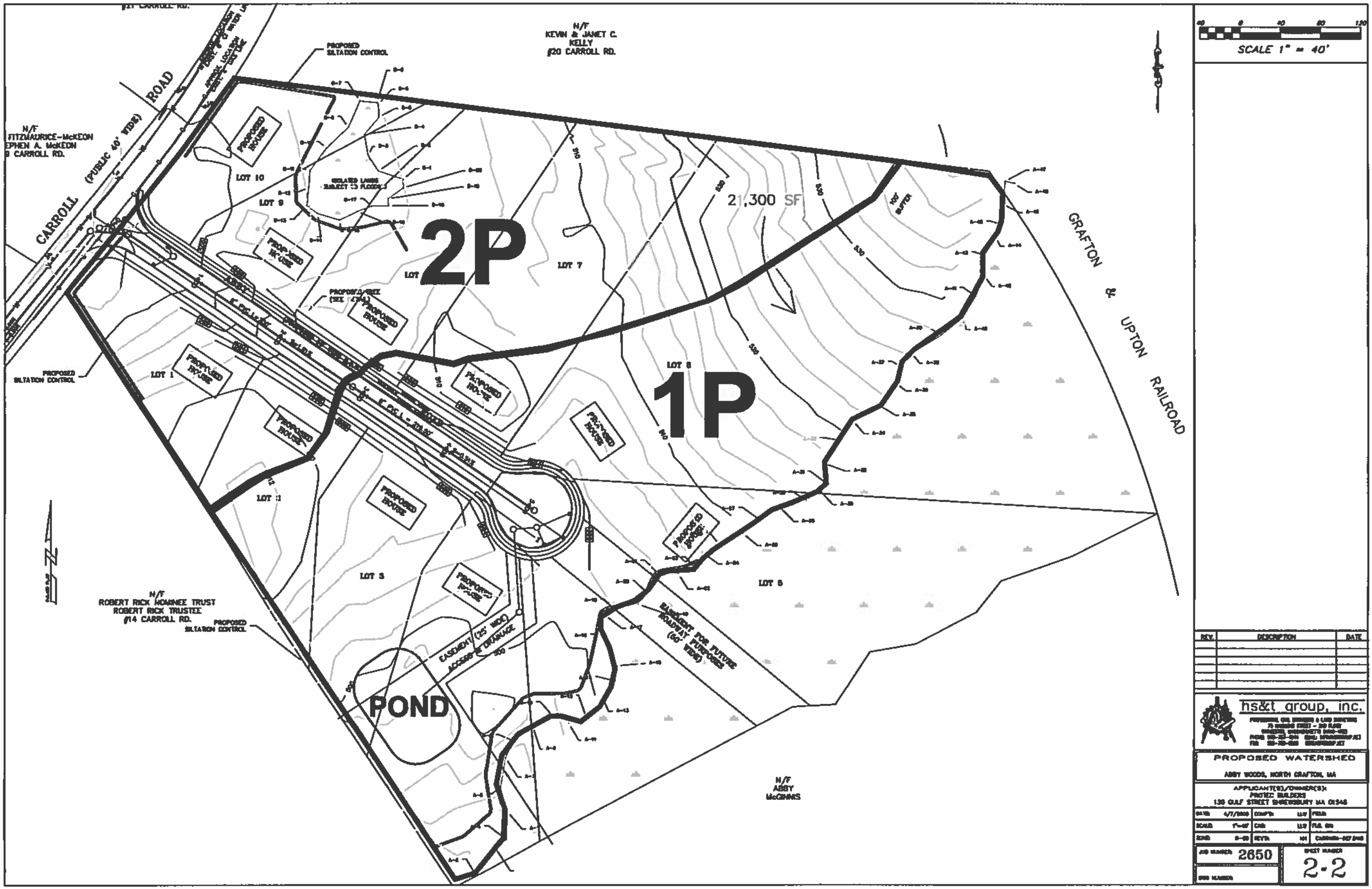
The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/13/2020 at 2:04:06 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX G:

Pre-development catchment locations
Post-development catchment locations


SCALE 1" = 40'
N/F
KEVIN & JANET C.
KELLY
CARROLL (PUBLIC 40' WIDE) ROAD
N/F
ROBERT RICK NOMINEE TRUST
ROBERT RICK TRUSTEE
N/F
ABBY
McGINNIS
GRAFTON & UPTON RAILROAD
2E
1E
EXISTING HOUSE
TO BE REMOVED
ISOLATED LANDS
SUBJECT TO FLOODING
500
510
520
530
REV.
DESCRIPTION
DATE
hs&t group, inc.
EXISTING WATERSHED
ABBY WOODS, NORTH GRAFTON, MA
APPLICANT(S)/OWNER(S):
130 GULF STREET SHREWSBURY MA 01545
2650
1-2


SCALE 1" = 40'
N/F
KEVIN & JANET C.
KELLY
#20 CARROLL RD.
N/F
FITZMAURICE-McKEON
EPHEN A. McKEON
9 CARROLL RD.
CARROLL (PUBLIC 40' WIDE) ROAD
PROPOSED
SILTATION CONTROL
LOT 10
LOT 9
LOT 7
LOT 8
LOT 1
LOT 11
LOT 3
LOT 5
2P
1P
21,300 SF
PROPOSED HOUSE
GRAFTON & UPTON RAILROAD
EASEMENT FOR FUTURE ROADWAY PURPOSES (60' WIDE)
EASEMENT (25' WIDE) ACCESS & DRAINAGE
POND
N/F
ROBERT RICK NOMINEE TRUST
ROBERT RICK TRUSTEE
#14 CARROLL RD.
N/F
ABBY
McGINNIS
REV.
DESCRIPTION
DATE
hs&t group, inc.
PROPOSED WATERSHED
ABBY WOODS, NORTH GRAFTON, MA
PROTEC BUILDERS
130 GULF STREET SHREWSBURY MA 01545
2650
2-2

APPENDIX H:

Pre-Development Hydrology for POI

Type III, 2-Year 24 Hour Storm

Type III, 10-Year 24 Hour Storm

Type III, 100-Year 24 Hour Storm

APPENDIX I:

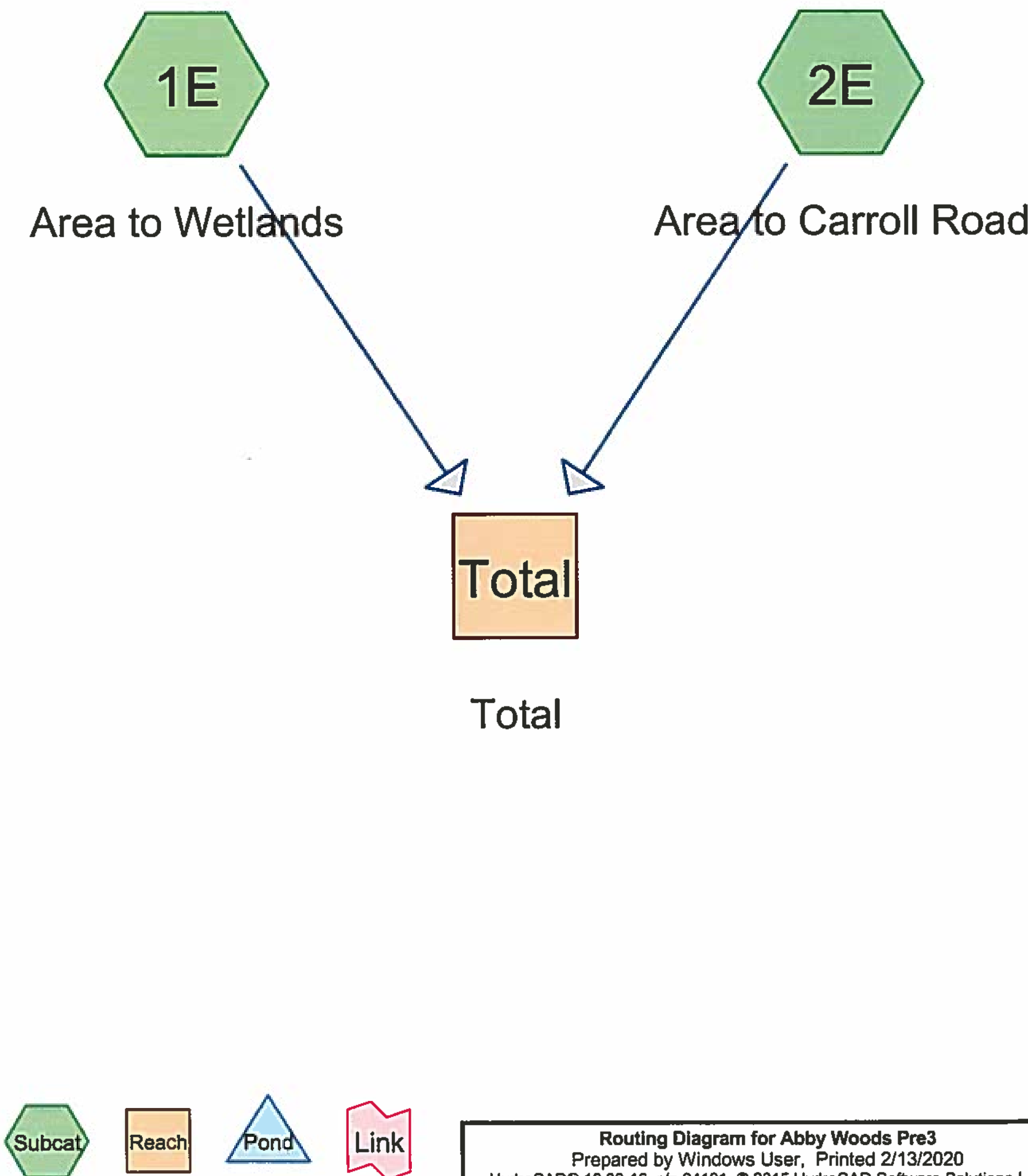
Post-Development Hydrology for POI

25-yr Storm Drain Sizing Computations

Type III, 2-Year 24 Hour Storm

Type III, 10-Year 24 Hour Storm

Type III, 100-Year 24 Hour Storm



Routing Diagram for Abby Woods Pre3
Prepared by Windows User, Printed 2/13/2020

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1E: Area to Wetlands Runoff Area=4.710 ac 0.00% Impervious Runoff Depth>0.88"
Flow Length=725' Slope=0.0530 '/' Tc=13.5 min CN=72 Runoff=3.88 cfs 0.346 af

Subcatchment 2E: Area to Carroll Road Runoff Area=4.230 ac 1.18% Impervious Runoff Depth>1.04"
Flow Length=790' Slope=0.0440 '/' Tc=14.6 min CN=75 Runoff=4.12 cfs 0.367 af

Reach Total: Total Inflow=7.99 cfs 0.713 af
Outflow=7.99 cfs 0.713 af

Total Runoff Area = 8.940 ac Runoff Volume = 0.713 af Average Runoff Depth = 0.96"
99.44% Pervious = 8.890 ac 0.56% Impervious = 0.050 ac

Summary for Subcatchment 1E: Area to Wetlands

Runoff = 3.88 cfs @ 12.21 hrs, Volume= 0.346 af, Depth> 0.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2yr Rainfall=3.27"

Area (ac)	CN	Description
2.930	74	>75% Grass cover, Good, HSG C
1.780	70	Woods, Good, HSG C
4.710	72	Weighted Average
4.710		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	725	0.0530	0.90		**Lag/CN Method,**

Summary for Subcatchment 2E: Area to Carroll Road

Runoff = 4.12 cfs @ 12.22 hrs, Volume= 0.367 af, Depth> 1.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2yr Rainfall=3.27"

Area (ac)	CN	Description
0.050	98	Paved parking & roofs
0.110	89	Gravel roads, HSG C
3.180	75	>75% Grass cover, Good, HSG C
0.890	70	Woods, Good, HSG C
4.230	75	Weighted Average
4.180		98.82% Pervious Area
0.050		1.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	790	0.0440	0.90		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 8.940 ac, 0.56% Impervious, Inflow Depth > 0.96" for 2yr event
Inflow = 7.99 cfs @ 12.21 hrs, Volume= 0.713 af
Outflow = 7.99 cfs @ 12.21 hrs, Volume= 0.713 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1E: Area to Wetlands Runoff Area=4.710 ac 0.00% Impervious Runoff Depth>2.05"
Flow Length=725' Slope=0.0530 '/' Tc=13.5 min CN=72 Runoff=9.50 cfs 0.806 af

Subcatchment 2E: Area to Carroll Road Runoff Area=4.230 ac 1.18% Impervious Runoff Depth>2.30"
Flow Length=790' Slope=0.0440 '/' Tc=14.6 min CN=75 Runoff=9.33 cfs 0.809 af

Reach Total: Total Inflow=18.81 cfs 1.615 af
Outflow=18.81 cfs 1.615 af

Total Runoff Area = 8.940 ac Runoff Volume = 1.615 af Average Runoff Depth = 2.17"
99.44% Pervious = 8.890 ac 0.56% Impervious = 0.050 ac

Summary for Subcatchment 1E: Area to Wetlands

Runoff = 9.50 cfs @ 12.20 hrs, Volume= 0.806 af, Depth> 2.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10yr Rainfall=5.04"

Area (ac)	CN	Description
2.930	74	>75% Grass cover, Good, HSG C
1.780	70	Woods, Good, HSG C
4.710	72	Weighted Average
4.710		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	725	0.0530	0.90		**Lag/CN Method,**

Summary for Subcatchment 2E: Area to Carroll Road

Runoff = 9.33 cfs @ 12.21 hrs, Volume= 0.809 af, Depth> 2.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10yr Rainfall=5.04"

Area (ac)	CN	Description
0.050	98	Paved parking & roofs
0.110	89	Gravel roads, HSG C
3.180	75	>75% Grass cover, Good, HSG C
0.890	70	Woods, Good, HSG C
4.230	75	Weighted Average
4.180		98.82% Pervious Area
0.050		1.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	790	0.0440	0.90		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 8.940 ac, 0.56% Impervious, Inflow Depth > 2.17" for 10yr event
Inflow = 18.81 cfs @ 12.20 hrs, Volume= 1.615 af
Outflow = 18.81 cfs @ 12.20 hrs, Volume= 1.615 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1E: Area to Wetlands Runoff Area=4.710 ac 0.00% Impervious Runoff Depth>2.88"
Flow Length=725' Slope=0.0530 '/' Tc=13.5 min CN=72 Runoff=13.37 cfs 1.130 af

Subcatchment 2E: Area to Carroll Road Runoff Area=4.230 ac 1.18% Impervious Runoff Depth>3.16"
Flow Length=790' Slope=0.0440 '/' Tc=14.6 min CN=75 Runoff=12.84 cfs 1.115 af

Reach Total: Total Inflow=26.19 cfs 2.245 af
Outflow=26.19 cfs 2.245 af

Total Runoff Area = 8.940 ac Runoff Volume = 2.245 af Average Runoff Depth = 3.01"
99.44% Pervious = 8.890 ac 0.56% Impervious = 0.050 ac

Summary for Subcatchment 1E: Area to Wetlands

Runoff = 13.37 cfs @ 12.19 hrs, Volume= 1.130 af, Depth> 2.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25yr Rainfall=6.14"

Area (ac)	CN	Description
2.930	74	>75% Grass cover, Good, HSG C
1.780	70	Woods, Good, HSG C
4.710	72	Weighted Average
4.710		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	725	0.0530	0.90		**Lag/CN Method,**

Summary for Subcatchment 2E: Area to Carroll Road

Runoff = 12.84 cfs @ 12.20 hrs, Volume= 1.115 af, Depth> 3.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25yr Rainfall=6.14"

Area (ac)	CN	Description
0.050	98	Paved parking & roofs
0.110	89	Gravel roads, HSG C
3.180	75	>75% Grass cover, Good, HSG C
0.890	70	Woods, Good, HSG C
4.230	75	Weighted Average
4.180		98.82% Pervious Area
0.050		1.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	790	0.0440	0.90		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 8.940 ac, 0.56% Impervious, Inflow Depth > 3.01" for 25yr event
Inflow = 26.19 cfs @ 12.20 hrs, Volume= 2.245 af
Outflow = 26.19 cfs @ 12.20 hrs, Volume= 2.245 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1E: Area to Wetlands Runoff Area=4.710 ac 0.00% Impervious Runoff Depth>4.24"
Flow Length=725' Slope=0.0530 '/' Tc=13.5 min CN=72 Runoff=19.64 cfs 1.666 af

Subcatchment 2E: Area to Carroll Road Runoff Area=4.230 ac 1.18% Impervious Runoff Depth>4.58"
Flow Length=790' Slope=0.0440 '/' Tc=14.6 min CN=75 Runoff=18.44 cfs 1.613 af

Reach Total: Total Inflow=38.04 cfs 3.279 af
Outflow=38.04 cfs 3.279 af

Total Runoff Area = 8.940 ac Runoff Volume = 3.279 af Average Runoff Depth = 4.40"
99.44% Pervious = 8.890 ac 0.56% Impervious = 0.050 ac

Summary for Subcatchment 1E: Area to Wetlands

Runoff = 19.64 cfs @ 12.19 hrs, Volume= 1.666 af, Depth> 4.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100yr Rainfall=7.84"

Area (ac)	CN	Description
2.930	74	>75% Grass cover, Good, HSG C
1.780	70	Woods, Good, HSG C
4.710	72	Weighted Average
4.710		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	725	0.0530	0.90		**Lag/CN Method,**

Summary for Subcatchment 2E: Area to Carroll Road

Runoff = 18.44 cfs @ 12.20 hrs, Volume= 1.613 af, Depth> 4.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100yr Rainfall=7.84"

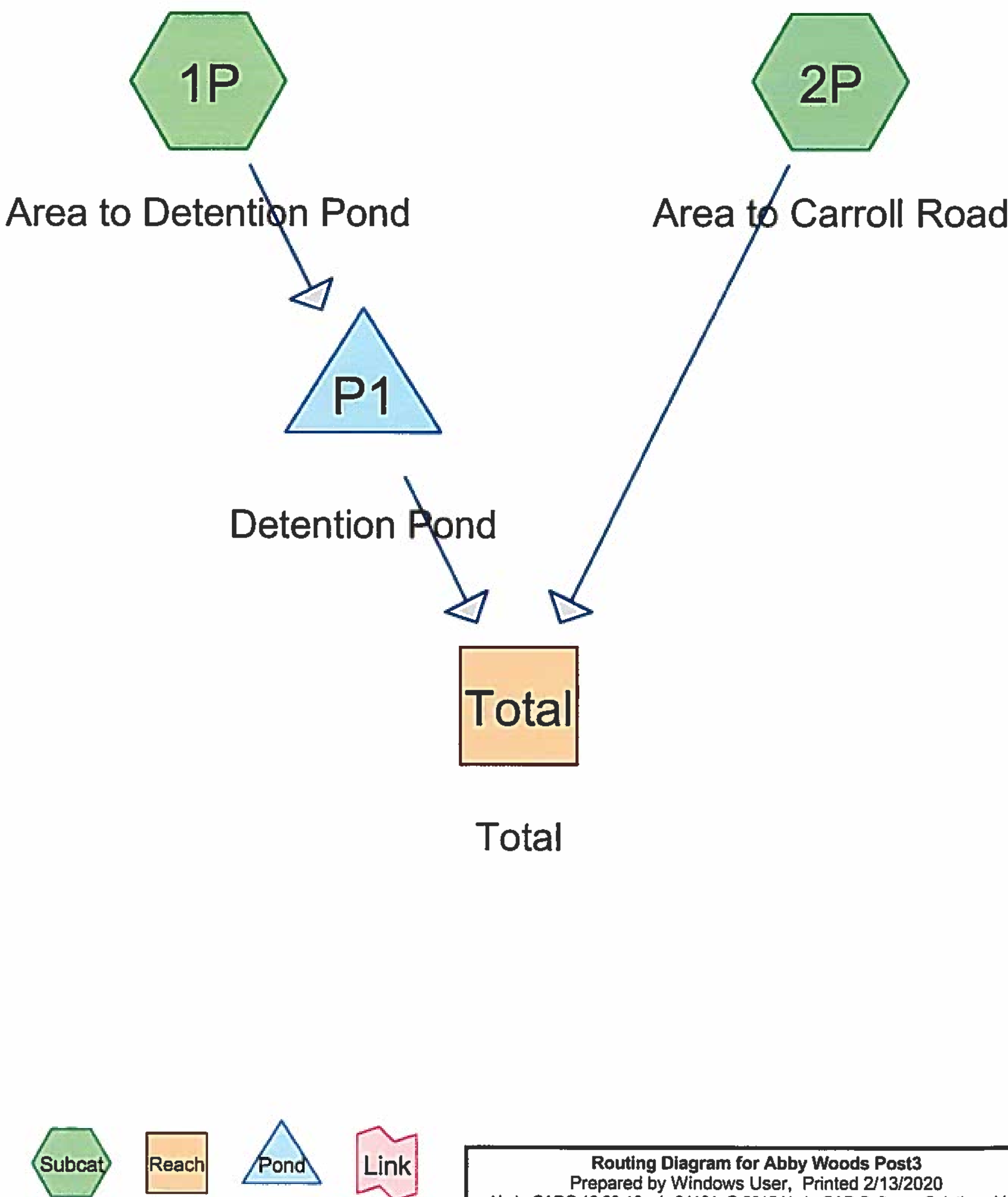
Area (ac)	CN	Description
0.050	98	Paved parking & roofs
0.110	89	Gravel roads, HSG C
3.180	75	>75% Grass cover, Good, HSG C
0.890	70	Woods, Good, HSG C
4.230	75	Weighted Average
4.180		98.82% Pervious Area
0.050		1.18% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.6	790	0.0440	0.90		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 8.940 ac, 0.56% Impervious, Inflow Depth > 4.40" for 100yr event
Inflow = 38.04 cfs @ 12.20 hrs, Volume= 3.279 af
Outflow = 38.04 cfs @ 12.20 hrs, Volume= 3.279 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs



Routing Diagram for Abby Woods Post3
Prepared by Windows User, Printed 2/13/2020
HydroCAD® 10.00-16 s/n 04131 © 2015 HydroCAD Software Solutions LLC

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1P: Area to Detention Pond Runoff Area=5.550 ac 8.11% Impervious Runoff Depth>1.04"
Flow Length=725' Slope=0.0530 '/' Tc=12.4 min CN=75 Runoff=5.70 cfs 0.482 af

Subcatchment 2P: Area to Carroll Road Runoff Area=3.660 ac 12.30% Impervious Runoff Depth>1.16"
Flow Length=790' Slope=0.0440 '/' Tc=13.7 min CN=77 Runoff=4.09 cfs 0.353 af

Reach Total: Total Inflow=6.49 cfs 0.810 af
Outflow=6.49 cfs 0.810 af

Pond P1: Detention Pond Peak Elev=497.17' Storage=5,122 cf Inflow=5.70 cfs 0.482 af
Outflow=3.36 cfs 0.458 af

Total Runoff Area = 9.210 ac Runoff Volume = 0.834 af Average Runoff Depth = 1.09"
90.23% Pervious = 8.310 ac 9.77% Impervious = 0.900 ac

Summary for Subcatchment 1P: Area to Detention Pond

Runoff = 5.70 cfs @ 12.19 hrs, Volume= 0.482 af, Depth> 1.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2yr Rainfall=3.27"

Area (ac)	CN	Description
3.810	74	>75% Grass cover, Good, HSG C
1.290	70	Woods, Good, HSG C
0.450	98	Paved parking & roofs
5.550	75	Weighted Average
5.100		91.89% Pervious Area
0.450		8.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	725	0.0530	0.98		**Lag/CN Method,**

Summary for Subcatchment 2P: Area to Carroll Road

Runoff = 4.09 cfs @ 12.20 hrs, Volume= 0.353 af, Depth> 1.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2yr Rainfall=3.27"

Area (ac)	CN	Description
0.450	98	Paved parking & roofs
2.810	74	>75% Grass cover, Good, HSG C
0.400	70	Woods, Good, HSG C
3.660	77	Weighted Average
3.210		87.70% Pervious Area
0.450		12.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	790	0.0440	0.96		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 9.210 ac, 9.77% Impervious, Inflow Depth > 1.06" for 2yr event
Inflow = 6.49 cfs @ 12.27 hrs, Volume= 0.810 af
Outflow = 6.49 cfs @ 12.27 hrs, Volume= 0.810 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Detention Pond

Inflow Area = 5.550 ac, 8.11% Impervious, Inflow Depth > 1.04" for 2yr event
Inflow = 5.70 cfs @ 12.19 hrs, Volume= 0.482 af
Outflow = 3.36 cfs @ 12.43 hrs, Volume= 0.458 af, Atten= 41%, Lag= 14.5 min
Primary = 3.36 cfs @ 12.43 hrs, Volume= 0.458 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 497.17' @ 12.43 hrs Surf.Area= 3,762 sf Storage= 5,122 cf

Plug-Flow detention time= 46.0 min calculated for 0.458 af (95% of inflow)
Center-of-Mass det. time= 28.6 min (848.4 - 819.8)

Volume	Invert	Avail.Storage	Storage Description
#1	495.30'	27,184 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
495.30	1,199	0	0
496.00	2,666	1,353	1,353
498.00	4,536	7,202	8,555
500.00	6,808	11,344	19,899
501.00	7,763	7,286	27,184

Device	Routing	Invert	Outlet Devices
#1	Primary	495.30'	**18.0" Round Culvert** L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 495.30' / 495.10' S= 0.0067 '/' Cc= 0.900 n= 0.011, Flow Area= 1.77 sf
#2	Device 1	495.30'	**30.0 deg V-Notch Weir** Cv= 2.61 (C= 3.26)

Primary OutFlow Max=3.35 cfs @ 12.43 hrs HW=497.17' TW=0.00' (Dynamic Tailwater)
└1=**Culvert** (Passes 3.35 cfs of 8.35 cfs potential flow)
  └2=**V-Notch Weir** (Weir Controls 3.35 cfs @ 3.57 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1P: Area to Detention Pond Runoff Area=5.550 ac 8.11% Impervious Runoff Depth>2.30"
Flow Length=725' Slope=0.0530 '/' Tc=12.4 min CN=75 Runoff=12.89 cfs 1.063 af

Subcatchment 2P: Area to Carroll Road Runoff Area=3.660 ac 12.30% Impervious Runoff Depth>2.47"
Flow Length=790' Slope=0.0440 '/' Tc=13.7 min CN=77 Runoff=8.85 cfs 0.752 af

Reach Total: Total Inflow=17.01 cfs 1.782 af
Outflow=17.01 cfs 1.782 af

Pond P1: Detention Pond Peak Elev=498.12' Storage=9,104 cf Inflow=12.89 cfs 1.063 af
Outflow=9.33 cfs 1.030 af

Total Runoff Area = 9.210 ac Runoff Volume = 1.815 af Average Runoff Depth = 2.36"
90.23% Pervious = 8.310 ac 9.77% Impervious = 0.900 ac

Summary for Subcatchment 1P: Area to Detention Pond

Runoff = 12.89 cfs @ 12.18 hrs, Volume= 1.063 af, Depth> 2.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10yr Rainfall=5.04"

Area (ac)	CN	Description
3.810	74	>75% Grass cover, Good, HSG C
1.290	70	Woods, Good, HSG C
0.450	98	Paved parking & roofs
5.550	75	Weighted Average
5.100		91.89% Pervious Area
0.450		8.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	725	0.0530	0.98		**Lag/CN Method,**

Summary for Subcatchment 2P: Area to Carroll Road

Runoff = 8.85 cfs @ 12.19 hrs, Volume= 0.752 af, Depth> 2.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10yr Rainfall=5.04"

Area (ac)	CN	Description
0.450	98	Paved parking & roofs
2.810	74	>75% Grass cover, Good, HSG C
0.400	70	Woods, Good, HSG C
3.660	77	Weighted Average
3.210		87.70% Pervious Area
0.450		12.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	790	0.0440	0.96		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 9.210 ac, 9.77% Impervious, Inflow Depth > 2.32" for 10yr event
Inflow = 17.01 cfs @ 12.25 hrs, Volume= 1.782 af
Outflow = 17.01 cfs @ 12.25 hrs, Volume= 1.782 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Detention Pond

Inflow Area =	5.550 ac,	8.11% Impervious,	Inflow Depth > 2.30"	for 10yr event
Inflow =	12.89 cfs @	12.18 hrs, Volume=	1.063 af	
Outflow =	9.33 cfs @	12.32 hrs, Volume=	1.030 af, Atten= 28%, Lag= 8.7 min	
Primary =	9.33 cfs @	12.32 hrs, Volume=	1.030 af	

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 498.12' @ 12.32 hrs Surf.Area= 4,672 sf Storage= 9,104 cf

Plug-Flow detention time= 33.1 min calculated for 1.030 af (97% of inflow)
Center-of-Mass det. time= 21.6 min (823.8 - 802.2)

Volume	Invert	Avail.Storage	Storage Description
#1	495.30'	27,184 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
495.30	1,199	0	0
496.00	2,666	1,353	1,353
498.00	4,536	7,202	8,555
500.00	6,808	11,344	19,899
501.00	7,763	7,286	27,184

Device	Routing	Invert	Outlet Devices
#1	Primary	495.30'	**18.0" Round Culvert** L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 495.30' / 495.10' S= 0.0067 '/' Cc= 0.900 n= 0.011, Flow Area= 1.77 sf
#2	Device 1	495.30'	**30.0 deg V-Notch Weir** Cv= 2.61 (C= 3.26)

Primary OutFlow Max=9.27 cfs @ 12.32 hrs HW=498.11' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 9.27 cfs of 12.22 cfs potential flow)
  └─**2=V-Notch Weir** (Weir Controls 9.27 cfs @ 4.38 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1P: Area to Detention Pond Runoff Area=5.550 ac 8.11% Impervious Runoff Depth>3.17"
Flow Length=725' Slope=0.0530 '/' Tc=12.4 min CN=75 Runoff=17.87 cfs 1.464 af

Subcatchment 2P: Area to Carroll Road Runoff Area=3.660 ac 12.30% Impervious Runoff Depth>3.36"
Flow Length=790' Slope=0.0440 '/' Tc=13.7 min CN=77 Runoff=12.01 cfs 1.024 af

Reach Total: Total Inflow=24.19 cfs 2.450 af
Outflow=24.19 cfs 2.450 af

Pond P1: Detention Pond Peak Elev=498.57' Storage=11,306 cf Inflow=17.87 cfs 1.464 af
Outflow=13.49 cfs 1.426 af

Total Runoff Area = 9.210 ac Runoff Volume = 2.488 af Average Runoff Depth = 3.24"
90.23% Pervious = 8.310 ac 9.77% Impervious = 0.900 ac

Summary for Subcatchment 1P: Area to Detention Pond

Runoff = 17.87 cfs @ 12.17 hrs, Volume= 1.464 af, Depth> 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25yr Rainfall=6.14"

Area (ac)	CN	Description
3.810	74	>75% Grass cover, Good, HSG C
1.290	70	Woods, Good, HSG C
0.450	98	Paved parking & roofs
5.550	75	Weighted Average
5.100		91.89% Pervious Area
0.450		8.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	725	0.0530	0.98		**Lag/CN Method,**

Summary for Subcatchment 2P: Area to Carroll Road

Runoff = 12.01 cfs @ 12.19 hrs, Volume= 1.024 af, Depth> 3.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25yr Rainfall=6.14"

Area (ac)	CN	Description
0.450	98	Paved parking & roofs
2.810	74	>75% Grass cover, Good, HSG C
0.400	70	Woods, Good, HSG C
3.660	77	Weighted Average
3.210		87.70% Pervious Area
0.450		12.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	790	0.0440	0.96		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 9.210 ac, 9.77% Impervious, Inflow Depth > 3.19" for 25yr event
Inflow = 24.19 cfs @ 12.24 hrs, Volume= 2.450 af
Outflow = 24.19 cfs @ 12.24 hrs, Volume= 2.450 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Detention Pond

Inflow Area = 5.550 ac, 8.11% Impervious, Inflow Depth > 3.17" for 25yr event
Inflow = 17.87 cfs @ 12.17 hrs, Volume= 1.464 af
Outflow = 13.49 cfs @ 12.30 hrs, Volume= 1.426 af, Atten= 25%, Lag= 7.6 min
Primary = 13.49 cfs @ 12.30 hrs, Volume= 1.426 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 498.57' @ 12.30 hrs Surf.Area= 5,179 sf Storage= 11,306 cf

Plug-Flow detention time= 29.2 min calculated for 1.421 af (97% of inflow)
Center-of-Mass det. time= 19.5 min (814.5 - 795.0)

Volume	Invert	Avail.Storage	Storage Description
#1	495.30'	27,184 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
495.30	1,199	0	0
496.00	2,666	1,353	1,353
498.00	4,536	7,202	8,555
500.00	6,808	11,344	19,899
501.00	7,763	7,286	27,184

Device	Routing	Invert	Outlet Devices
#1	Primary	495.30'	**18.0" Round Culvert** L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 495.30' / 495.10' S= 0.0067 '/' Cc= 0.900 n= 0.011, Flow Area= 1.77 sf
#2	Device 1	495.30'	**30.0 deg V-Notch Weir** Cv= 2.61 (C= 3.26)

Primary OutFlow Max=13.48 cfs @ 12.30 hrs HW=498.57' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 13.48 cfs of 13.50 cfs potential flow)
  └─**2=V-Notch Weir** (Weir Controls 13.48 cfs @ 4.72 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1P: Area to Detention Pond Runoff Area=5.550 ac 8.11% Impervious Runoff Depth>4.58"
Flow Length=725' Slope=0.0530 '/' Tc=12.4 min CN=75 Runoff=25.67 cfs 2.118 af

Subcatchment 2P: Area to Carroll Road Runoff Area=3.660 ac 12.30% Impervious Runoff Depth>4.80"
Flow Length=790' Slope=0.0440 '/' Tc=13.7 min CN=77 Runoff=17.01 cfs 1.465 af

Reach Total: Total Inflow=31.80 cfs 3.539 af
Outflow=31.80 cfs 3.539 af

Pond P1: Detention Pond Peak Elev=499.52' Storage=16,773 cf Inflow=25.67 cfs 2.118 af
Outflow=15.85 cfs 2.074 af

Total Runoff Area = 9.210 ac Runoff Volume = 3.583 af Average Runoff Depth = 4.67"
90.23% Pervious = 8.310 ac 9.77% Impervious = 0.900 ac

Summary for Subcatchment 1P: Area to Detention Pond

Runoff = 25.67 cfs @ 12.17 hrs, Volume= 2.118 af, Depth> 4.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100yr Rainfall=7.84"

Area (ac)	CN	Description
3.810	74	>75% Grass cover, Good, HSG C
1.290	70	Woods, Good, HSG C
0.450	98	Paved parking & roofs
5.550	75	Weighted Average
5.100		91.89% Pervious Area
0.450		8.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.4	725	0.0530	0.98		**Lag/CN Method,**

Summary for Subcatchment 2P: Area to Carroll Road

Runoff = 17.01 cfs @ 12.19 hrs, Volume= 1.465 af, Depth> 4.80"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100yr Rainfall=7.84"

Area (ac)	CN	Description
0.450	98	Paved parking & roofs
2.810	74	>75% Grass cover, Good, HSG C
0.400	70	Woods, Good, HSG C
3.660	77	Weighted Average
3.210		87.70% Pervious Area
0.450		12.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	790	0.0440	0.96		**Lag/CN Method,**

Summary for Reach Total: Total

Inflow Area = 9.210 ac, 9.77% Impervious, Inflow Depth > 4.61" for 100yr event
Inflow = 31.80 cfs @ 12.21 hrs, Volume= 3.539 af
Outflow = 31.80 cfs @ 12.21 hrs, Volume= 3.539 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Detention Pond

Inflow Area = 5.550 ac, 8.11% Impervious, Inflow Depth > 4.58" for 100yr event
Inflow = 25.67 cfs @ 12.17 hrs, Volume= 2.118 af
Outflow = 15.85 cfs @ 12.36 hrs, Volume= 2.074 af, Atten= 38%, Lag= 11.3 min
Primary = 15.85 cfs @ 12.36 hrs, Volume= 2.074 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 499.52' @ 12.36 hrs Surf.Area= 6,265 sf Storage= 16,773 cf

Plug-Flow detention time= 26.5 min calculated for 2.067 af (98% of inflow)
Center-of-Mass det. time= 18.5 min (805.0 - 786.5)

Volume	Invert	Avail.Storage	Storage Description
#1	495.30'	27,184 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
495.30	1,199	0	0
496.00	2,666	1,353	1,353
498.00	4,536	7,202	8,555
500.00	6,808	11,344	19,899
501.00	7,763	7,286	27,184

Device	Routing	Invert	Outlet Devices
#1	Primary	495.30'	**18.0" Round Culvert** L= 30.0' Ke= 0.500 Inlet / Outlet Invert= 495.30' / 495.10' S= 0.0067 '/' Cc= 0.900 n= 0.011, Flow Area= 1.77 sf
#2	Device 1	495.30'	**30.0 deg V-Notch Weir** Cv= 2.61 (C= 3.26)

Primary OutFlow Max=15.84 cfs @ 12.36 hrs HW=499.52' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 15.84 cfs @ 8.97 fps)
  └─**2=V-Notch Weir** (Passes 15.84 cfs of 25.54 cfs potential flow)

APPENDIX J:

Soil evaluation reports and perc test results

Massachusetts Department of Environmental Protection
Bureau of Resource Protection – Wastewater Permitting Program

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Site Address or Map/Lot Number

Deep Observation Hole A: Deep Hole Number: 1@ Sta 1400

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0"-12"	AP	10YR 5/3	N/A			S.L			Blocky		
12"-32"	BW	10YR 5/5	NA			S.L			MASSIVE	720%	
32"-118"	C	10YR 6/3	59"	7.5YR 6/6		S.L	730%		FRIABLE		
	Seepage		118"								
	∇ @		130"								
	Mottles @		59"								

Additional Notes Note Observations taken From Existing Grade
No Ramp For Observations Existed

Massachusetts Department of Environmental Protection
Bureau of Resource Protection – Wastewater Permitting Program
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Site Address or Map/Lot Number

Deep Observation Hole A: Deep Hole Number: 2@ sta 3+

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0"-11"	Ap	10YR 3/4									
11"-23"	Bw	10YR 5/6									
23"-72"	C	10YR 4/3	35"	2.5YR 4/4							
Seepage None			▽ None								
Note: Hole Had collapsed by time evaluation was conducted											

Additional Notes

Massachusetts Department of Environmental Protection
Bureau of Resource Protection – Wastewater Permitting Program
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Site Address or Map/Lot Number: ____________

Deep Observation Hole B: Deep Hole Number: 3 @ 5100

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0"-12"	AP	10YR 3/2				SL			Blocky		
12"-26"	BW	10YR 5/4				SL			Blocky		
26" 172"	C	10YR 6/4	37"	PR 6/9	7.5YR 6/4	SL	7 25	7 40	friable	7 30%	
		Seepage NONE									
		▽ None									

Additional Notes ____________

Massachusetts Department of Environmental Protection
Bureau of Resource Protection – Wastewater Permitting Program
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Site Address or Map/Lot Number

Deep Observation Hole B: Deep Hole Number: @ proposed detention basin

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0" 13"	AP	10YR 3/2				S.L			Massive		
13" 33"	BW	10YR 5/3				S.L			friable		
33" 94"	C	10YR 6/4	37"	7.5YR 4/4 5YR 6/8		S.L	725	40 T	Very friable		
		Not: pockets of shale									
		Seepage NONE									
		▽ NONE									

Additional Notes

Massachusetts Department of Environmental Protection
Bureau of Resource Protection – Wastewater Permitting Program
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

____
Site Address or Map/Lot Number

D. Determination of High Groundwater Elevation

1. Method used:

- ☐ Depth observed standing water in observation hole A. ______ inches B. ______ inches
- ☐ Depth weeping from side of observation hole A. ______ inches B. ______ inches
- ☒ Depth to soil redoximorphic features (mottles) A. See various logs inches B. inches
- ☐ Groundwater adjustment (USGS methodology) A. ______ inches B. ______ inches

2. Index Well Number ______ Reading Date ______ Index Well Level ______

Adjustment Factor ______ Adjusted Groundwater Level ______

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for t soil absorption system? Yes ☑ No ☐

b. If yes, at what depth was it observed? Upper boundary: ______ inches Lower boundary: ______ inches

F. Certification

I certify that I have passed the soil evaluator examination* approved by the Department of Environmental Protection and that the abc analysis was performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017.

JoAnn Teschard — Signature of Soil Evaluator
11/20/03 — Date

JoAnn Teschard — Typed or Printed Name of Soil Evaluator
6/96 — *Date of Soil Evaluator Exam

______ Name of Board of Health Witness
______ Board of Health

Note: This form must be submitted to the approving authority with Percolation Test Form 12

Don evernett

Carrol RD
Grafton
Carroll

11-6-03

60°

4

elevations

2+0	1067	507.98
3+0	1068	507.88
4+0	1069	508.79

4 HOLES TOTAL